Understanding Economic Growth in the Northern Territory through the Solow Growth Model

Matteen Vahdat 2014

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Bachelor of Economics with Honours, Murdoch University, Western Australia

Declaration

I declare that this thesis is the result of my own research except as cited in the references. This thesis has not been submitted for a degree at any other tertiary education institution.

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Abstract

The Northern Territory is a unique jurisdiction that defies the Australian average in many ways. Recently, the smallest economy in the nation has experienced strong economic growth due to the expansion of the resources sector. The neoclassical growth model which was pioneered by Robert Solow (1956) proposes that sustained economic growth is almost entirely dependent on productivity growth. The central question becomes whether or not the Northern Territory's remarkable economic growth is sustainable in the long run. To answer this question the thesis estimates total factor productivity growth for the Northern Territory using the methodology employed by Krugman (1994) and Young (1994). This is accompanied by an outline of the model and its assumptions, a review of similar studies, and a trend analysis of key economic indicators for the Northern Territory. The thesis will then explore the policy implications of the findings.

Acknowledgements

My deepest gratitude to Dr Ranald Taylor, who gave me his time, guidance, and encouragement in writing this thesis. I wrote this thesis 2,500 kilometres away and I appreciated his calm assurance from afar. Above all, Dr Ranald Taylor's passion for the study of economics and his approach to empowering students to independently search for truth has been a source of inspiration to me, and for this I am very grateful.

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Finally, to my dearest wife who has accompanied me in this journey. I am sincerely thankful for her love, consideration and encouragement. With her by my side I understand the reality of the following quote… "*Joy gives us wings! In times of joy our strength is more vital, our intellect keener, and our understanding less clouded. We seem better able to cope with the world and to find our sphere of usefulness*".

Contents

Chapter 1 Introduction

1.1 Aim of the thesis

This thesis aims to understand the nature of the Northern Territory's economic growth between 1990 and 2013 using the Solow (1956) growth model as the framework of analysis.

Economic growth has concerned the individual, community, business, and government for many years; and in realising economic growth, people have sacrificed time, energy, resources and even the lives of others. It becomes vital then to understand economic growth, not only as a matter of academic interest but also of the wellbeing and advancement of society.

A useful way of analysing economic growth is by employing the 'growth accounting' method. This method assumes that economic growth comes from two sources, one is the increase of inputs, and the other is the increase of output per unit of input. The distinction between the two sources of economic growth has been an important consideration ever since Robert Solow found that economic growth driven only by an increase of inputs would eventually result in diminishing marginal returns, and that sustainable economic growth requires an increase of output per unit of input.

Robert Solow's (1956) growth model was used to study the remarkable economic expansion experienced in the Soviet Union during the 1950's and South East Asia during the 1990's. These studies found that economic growth in these economies was driven by an extraordinary mobilization of resources rather than an increase in productivity and thus was not sustainable (Krugman,1994).

The Northern Territory has also recently experienced remarkable economic expansion, with growth in output and investment outstripping all other jurisdictions in Australia. The Northern Territory is an interesting jurisdiction to study because in many ways it defies the average Australian experience – geographically, environmentally, socially and economically. It is also a jurisdiction that receives little attention when it comes to economic research. A question often asked in relation to the Northern Territory's remarkable economic expansion is whether or not it is sustainable in the long run, particularly in light of perceptions that it is being driven only by the resources sector.

The Solow (1956) growth model is a simple yet insightful framework for analysis that allows economic growth to be disaggregated into factor accumulation and technological progress. The extent to which technological progress is the driving force behind economic growth would, according to Solow (1956), determine whether economic growth can be sustained over the long run. However, while the Solow growth model can reveal the extent to which technological progress is the driving force behind economic growth, it cannot explain the cause of technological progress. The Solow growth model assumes that increases in productivity come from outside the economy and cannot be observed. This is a limitation of the model in regards to its ability to identify the key determinants of economic growth and the policy implications.

In summary, the central questions this thesis is concerned with are as follows: what are the characteristics of the Northern Territory's economic growth between 1990 and 2013; and is the economic growth currently experienced sustainable in the long run?

1.2 Structure

To approach these questions the thesis is structured as follows: Chapter 2 provides the theoretical foundations of the Solow (1956) growth model by outlining the underlying assumptions and findings of the model; Chapter 3 describes the salient characteristics of the Northern Territory by exploring the historic, geographic, and socio-demographic dynamics of the jurisdiction, followed by a trend analysis of the key economic indicators; Chapter 4 presents the empirical analysis and discussion on the results, accompanied by a discussion on the data and its limitations; Chapter 5 synthesises the findings from Chapters 3 and 4 and explores the policy implications, followed by the Conclusion.

Chapter 2 Theoretical Framework of the Solow Growth Model

2.1 Introduction

The Solow growth model, also known as the neoclassical model of economic growth, was developed by Robert Solow in 1956 in his seminal paper *A Contribution to the Theory of Economic Growth.* In the same year Trevor Swan independently developed the same model. While Solow and Swan followed a different approach to building their models, the assumptions and the conclusion were essentially the same.

Solow's motivation for developing the model came from his dissatisfaction with the assumptions underlying the Harrod (1939) and Domar (1946) growth model, which was the prevalent growth model of the time. So it would be useful to briefly look at the precursor first.

2.2 Development of the model

The primary finding of the Harrod (1939) – Domar (1946) growth model is that economic growth depends on capital accumulation, which depends on an increase in investment, which in turn depends on an increase in savings. The conclusion of the model is that policies are required to increase savings and investment, and that an economy does not find full employment or stable growth without this intervention. This conclusion is in line with the Keynesian school of thought.

Underlying this conclusion are a number of assumptions: (1) that output is a function of capital stock; (2) that the marginal product of capital is constant and the production function exhibits constant returns to scale; and (3) that the savings rate equals investment.

Solow (1956) was not comfortable with the assumptions made in the Harrod (1939) – Domar (1946) growth model. In his seminal paper, Solow considered that while all models depend on assumptions which “are not quite true”, the crucial assumptions need to be reasonably realistic, as the conclusion depends so much on it. The Harrod – Domar model proposes that in the long run the economic system requires a fine balance between the key parameters (the savings ratio, the capital-output ratio, and the rate of increase in the labour force) to achieve equilibrium growth. Solow considered this conclusion to be the result of dubious assumptions (Hagemann, 2009); namely the assumption that production takes place under conditions of fixed proportions, in that there is no possibility of substituting labour for capital in production. It was this assumption that Solow did not accept, and he devotes the rest of his paper to proposing a model of long-term economic growth which accepts all the Harrod (1939) – Domar (1946) assumptions except that of fixed proportions. The following sections describe the Solow (1956) growth model’s assumptions and dynamics.

2.3 Assumptions

This section outlines the Solow (1956) growth model’s assumptions. The assumptions of the Solow growth model can be divided into those concerning inputs and outputs, and those concerning the production function.

2.3.1 Assumptions concerning inputs and outputs

The Solow (1956) growth model focuses on four variables: Output *(Y)*, capital *(K)*, labour *(L)*, and technology *(A)*. Output consists of one commodity, and the rate of production for this commodity is *Y(t)*. Output refers to net output, which means depreciation of capital is already deducted. Part of the output is consumed and the rest is saved (Taylor, 2007). The part that is saved is a constant *s*, so that the rate of saving is *sY(t)*. The part that is saved is invested and added to the capital stock, which is assumed to be fully employed. Therefore the annual increase in capital stock is essentially net investment, and is expressed as such:

$$\dot{K}=\mathrm{s}Y_t \tag{2.1}$$

Where $\dot{K}$ indicates that K is differentiated with respect to time (t), and s is the marginal propensity to save.

Output is produced with two factors of production, labour and capital. The rate of input for labour is *L(t)*, and the labour force is fully employed. The labour force is assumed to increase at a constant rate *n*. So increases in the labour force can be expressed as:

$$L_t = L_0 e^{nt} \tag{2.2}$$

Solow (1956) noted that Equation (2.2) is essentially an inelastic labour supply curve. When supply of labour changes, the wage rate adjusts accordingly, ensuring that all labour is employed. Therefore the key assumption is that the unemployment rate is constant (Barro, 2008).

Technological change is assumed to be constant and is expressed by g. The state of technology can be described as such:

$$A_t = e^{gt} \tag{2.3}$$

2.3.2 Assumptions concerning the production function

The model assumes that a combination of capital, labour and technology creates output. Solow (1956) uses the Cobb-Douglas production function to formalise this interaction. Yet Solow first introduces the model using an unspecified production function, which allows him to demonstrate the model's general characteristics first. Solow expresses the production function as such:

$$Y = F(K,L) \tag{2.4}$$

Combining the production function and the increase of capital stock together gives:

$$K = sF(K,L) \tag{2.5}$$

Therefore, the basic equation which determines the time path of capital accumulation that must be followed if all available labour is to be employed is:

$$\dot{K} = sF(K, L_0e^{nt}) \tag{2.6}$$

Technological change is ignored in Equation 2.6 but will be introduced later.

A crucial assumption of the model is that production has constant returns to scale in its two factors (K and L). When inputs are increased by the factor λ, output is increased by the factor λ. This can be illustrated in the following equation:

$$f(\lambda K_t, \lambda L_t) = \lambda Y_t \qquad (2.7)$$

Another assumption is that there are no scarce non-augmentable resources in the growth model. This distinguishes the Solow model from the Ricardo model, which allows for non-augmentable resources such as land.

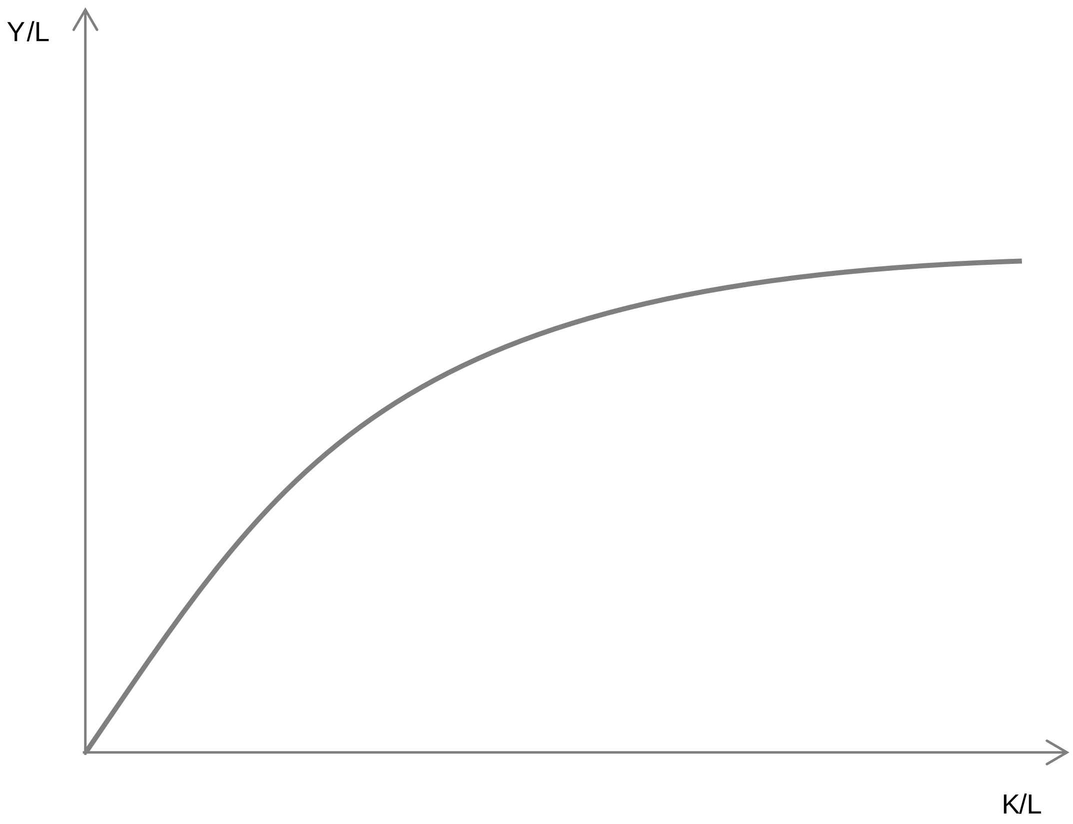
The last assumption is that the marginal productivity of both K and L is positive, but it is also diminishing. Therefore, the first derivative of output with respect to capital and labour is positive, while the second derivative is negative. As inputs increase, output increases; however because of diminishing marginal productivity, it increases at a decreasing rate.

$$\frac{dY}{dK} > 0, and \ \ \frac{d^2Y}{dK^2} < 0 \qquad (2.8)$$

$$\frac{dY}{dL} > 0, and \ \ \frac{d^2Y}{dL^2} < 0 \qquad (2.9)$$

Figure 2.1 illustrates the marginal productivity of the two factors (K and L) and that the production function is concave. It shows that while output keeps increasing with an increasing capital-labour ratio, the increase in output diminishes.

Figure 2.1: The Solow (1956) growth model's production function



2.4 Dynamics of the model

Solow (1956) derives the model under the assumption of no technological change and then introduces technological change. This section explores the dynamics of the Solow growth model in both phases.

2.4.1 The basic model without technological change

Solow (1956) first defines capital *(K)* and labour *(L)*, with these values then being used to determine output *(Y)*.

To determine the accumulation of the capital stock, Solow substituted the savings function (2.1) and the labour function (2.2) into his production function (2.4) to derive (2.6). Equation 2.6 gives the only values of K that fully employs the capital stock.

Next, Solow derives the time-path of labour which is consistent with the time-path of capital. Solow defines r as the ratio of capital to labour, $r = \frac{K}{L}$. Employing the solution to the labour function (2.2), Solow expresses the capital stock in terms of labour growth: $K = rL = r\, L_0 e^{nt}$. Differentiating K with respect to time by using both the product rule and the rule for differentiating exponents, Solow derives:

$$\dot{K} = \left(\frac{dr}{dt} \times L_0 e^{nt}\right) + (r \times nL_0 e^{nt}) \tag{2.10}$$

$$= \dot{r}\, L_0 e^{nt} + rn\, L_0 e^{nt} \tag{2.11}$$

Both Equations 2.6 and 2.11 describe K, equalising them Solow obtains:

$$s\, f\, (K, L_0 e^{nt}) = \dot{r} L_0 e^{nt} + r\, nL_0 e^{nt} \tag{2.12}$$

$$s\, f\, (K, L_0 e^{nt}) = (\dot{r} + nr)\, L_0 e^{nt} \tag{2.13}$$

Equation 2.13 is further simplified by dividing both variables in f by $L = L_0 e^{nt}$ and by multiplying f with the same factor:

$$s L_0 e^{nt}\ f\left(\frac{K}{L_0 e^{nt}}, 1\right) = (\dot{r} + n\, r)\, L_0 e^{nt} \tag{2.14}$$

Next, Solow divides both sides of Equation 2.14 with the common factor L_0e^{nt} :

$$sf(\frac{K}{L_0e^{nt}},1) = \dot{r} + nr \tag{2.15}$$

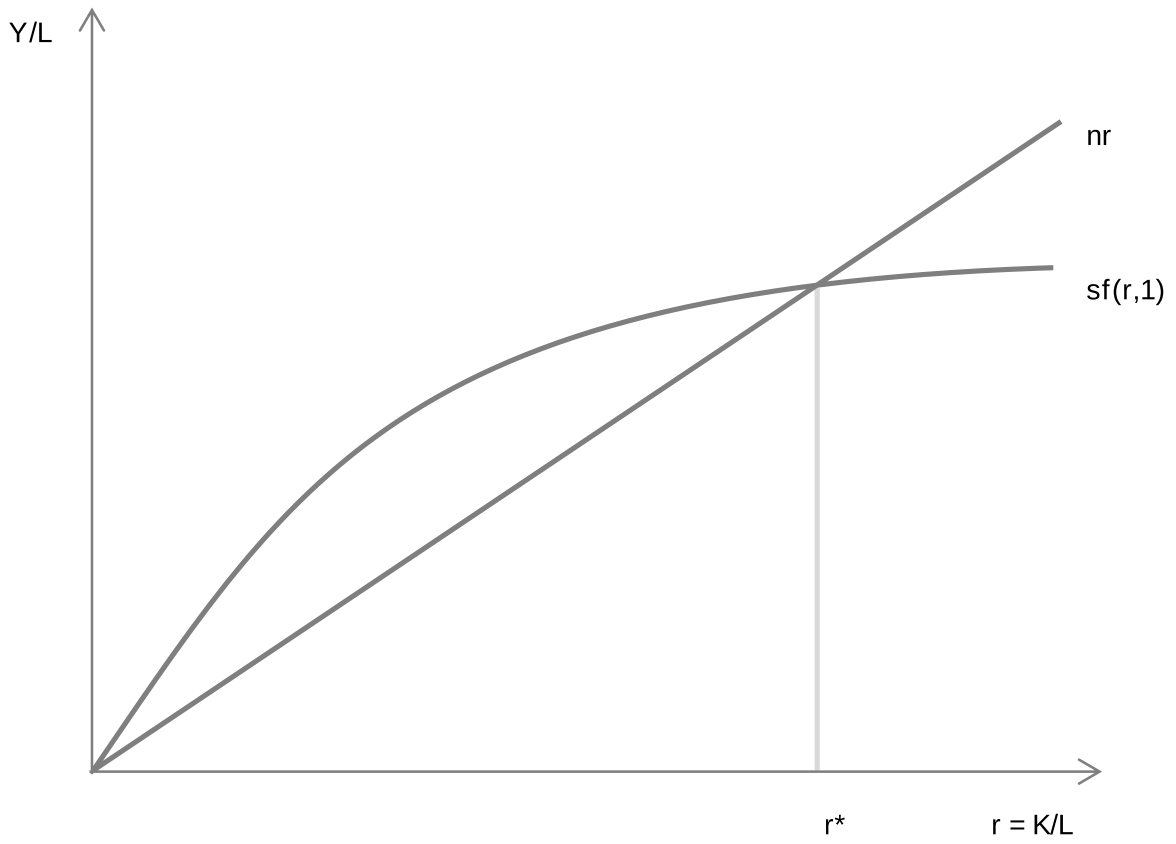
Finally, by substituting $\frac{K}{L_0e^{nt}}$ with r and by rearranging, Solow turns Equation 2.15 into his final equation:

$$\dot{r} = s\ f\ (r, 1) - nr \tag{2.16}$$

The value $\dot{r}$ gives the rate of change of the capital-labour ratio. It depends on the difference of *sf(r,1)* and *nr*. The function *f (r, 1)* is the total production curve with different levels of capital utilised while keeping employed labour constant at one unit. The second term, *nr* is the labour growth rate multiplied by the capital-labour ratio. This describes how much investment must rise to maintain a constant capital-labour ratio, given a specific growth rate of the labour force.

Figure 2.2 illustrates the Solow growth model diagram using the Cobb-Douglas production function.

Figure 2.2: The Solow (1956) growth model diagram



The horizontal axis of Figure 2.2 shows the capital-labour ratio and the vertical axis shows the output-labour ratio. The term nr is illustrated as a straight and upward sloping line. The function $sf(r,1)$ is described by a curve of which the slope goes towards zero as the capital-labour ratio increases. The decreasing slope is the result of the diminishing marginal productivity of capital and leads to the intersection of both lines at point r^*, at which point $\dot{r}$ equals zero.

2.4.2 The introduction of technological change

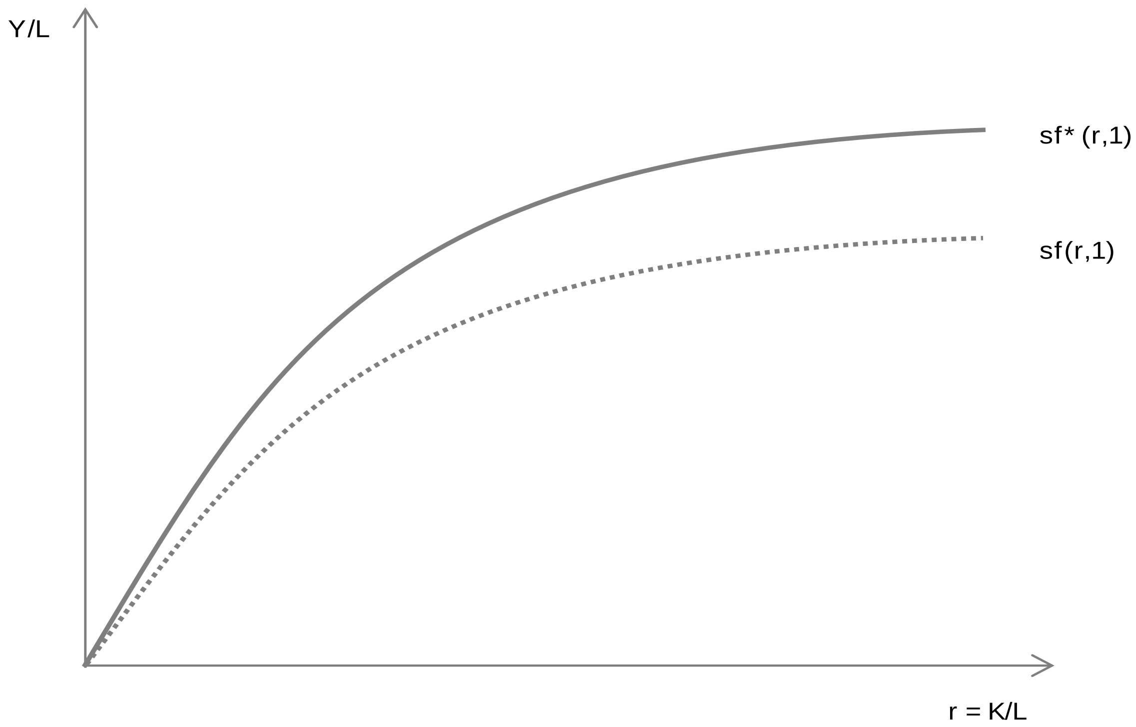
Before looking at the implication of the intersection point, it would be appropriate to outline how the model is adjusted when a constant rate of technological change is introduced. Solow (1956) explains that technological change multiplies the production function by an increasing scale factor. Therefore Equation 2.4 becomes:

$$Y_t = A_t f(K_t L_t) \tag{2.17}$$

Where A_t denotes the stance of technology at time t. Therefore Equation 2.17 simply implies that positive technological change increases output.

Figure 2.3 shows that positive technological change shifts the production function upwards.

Figure 2.3: The impact of positive technological progress on the production function



As shown in Figure 2.3, positive technological change enables an economy to create more output with the same level of capital and labour input. Therefore, technological change increases the capacity of the economy. To formally include technological change into the model, Solow (1956) defined $A_t = e^{gt}$ and recalibrated Equation 2.6 as a Cobb-Douglas type function as such:

$$\dot{K} = sA_t K^{\alpha} L^{\beta} \tag{2.18}$$

$$= se^{gt} K^{\alpha} (L_0 e^{nt})^{1-\alpha} \tag{2.19}$$

$$= sK^{\alpha} (L_0)^{1-\alpha} e^{(n(1-\alpha)+g)t} \tag{2.20}$$

Following the Cobb-Douglas production function, $\dot{K}$ can now be integrated into K, so Solow transformed Equation 2.20 to become:

$$K_t = [\, (K_0)^{\beta} - \frac{\beta s}{n\beta+g} (L_0)^{\beta} + \frac{\beta s}{n\beta+g} \left(L_0\right)^{\beta} e^{(n\beta+g)t} \,]^{\frac{1}{\beta}} \tag{2.21}$$

Where $\beta = 1 - \alpha$ because of constant returns to scale. After deriving K_t, Solow derives output Y_t by using the Cobb-Douglas production function.

Therefore, technological change brings about a new equilibrium point. At this point savings are higher, and as a result growth in capital stock increases, which in turn further increases economic growth. Technological change has a direct impact on economic growth through the shift of the production function; it also has an indirect impact from the increased growth of capital stock, which is the result of the increased growth of output.

2.4.3 The steady state

The point of intersection in Solow's graph (Figure 2.2) is a stable equilibrium, also referred to as 'the steady state' (Mankiw, 2007). At the steady state, labour, capital, and output grow at the same rate. As a result, per capita growth in output remains constant. Solow (1956) suggests that an economy is always converging towards the steady state.

Figure 2.2 illustrates that if the economy is to the left of the intersection point r^*, then r is less than r^*. In this case nr is smaller than $sf(r, 1)$. According to the implications of Equation 2.16, $\dot{r}$ is positive and therefore r will increase towards r^* over subsequent time periods. In contrast, if the economy is to the right of the intersection point r^* then nr will be greater than $sf(r, 1)$, and according to the implications of Equation 2.16 $\dot{r}$ will be negative, leading to a decrease in r over the following time periods. Thus, the economy will again move towards r^* (Taylor, 2007). As previously noted, the intersection point is the only point at which the economy experiences stable equilibrium. At any other point there is convergence towards the intersection point (Taylor, 2007).

2.5 Conclusion

This concludes the review of the Solow (1956) growth model, which will be utilised as the framework of analysis in understanding economic growth in the Northern Territory. In summary, the Solow (1956) growth model employs the Cobb-Douglas function to break down economic growth into capital accumulation, labour accumulation, and technological progress. Two key assumptions in the model are constant returns to scale and the diminishing marginal productivity of capital and labour. The model shows that the economy is always moving towards the 'steady state' point, where there is zero change in per capita capital stock and effectively no economic growth per capita. Technological progress increases output per unit of capital and labour, and increases the economies capacity to grow. However, the model cannot explain how technological progress occurs, and is therefore an “exogenous growth model”.

Chapter 3 Analysis of the Northern Territory Economy

3.1 Introduction

The purpose of this Chapter is to provide an overview of the Northern Territory economy. The history and socio-demographic characteristics of the Northern Territory are described for context, followed by a detailed trend analysis of the key economic indicators.

3.2 History of the Northern Territory

Human history in the Northern Territory started over 60,000 years ago when Indigenous Australians first settled in the region; an abundance of rock art throughout the North of the jurisdiction indicates a complex and spiritual culture (Murray 1998). It is thought that Makassan traders (from modern day Indonesia) started trading with Indigenous Australians in the North from the early 1700's (Spillet 1989). European settlement in Northern Australia came quite late in comparison with other parts of Australia due to its isolation and the climate. In 1863 the Northern Territory was annexed by South Australia. It was only in 1869, after four previous attempts to establish settlements in different parts of the Northern Territory, that George Goyder the Surveyor General of South Australia established a small settlement of over 130 men and women at Port Darwin (Cross 2010). A decade after the Australian federation was established, the Northern Territory was separated from South Australia and transferred to the Commonwealth in 1911 (Carney 2006). While under the administration of the Commonwealth some significant events included: a gold rush; bombardment by the Japanese during World War 2; civil unrest among the Indigenous population; the start of the Aboriginal land rights movement; and Cyclone Tracy which devastated the city of Darwin. In 1978 the Northern Territory was granted self-governance and a Legislative Assembly was established; the Act that conferred self-governance, is effectively the Northern Territory's constitution (Carney, 2006).

3.3 Dynamics of the Northern Territory

This section explores the social, demographic and environmental factors that influence the Northern Territory economy.

3.3.1 Size and remoteness

The Northern Territory is the third largest jurisdiction in Australia, following Western Australia and Queensland. The jurisdiction makes up 17 per cent of Australia's land mass (Geoscience Australia, 2014). The majority of the Northern Territory's land mass is classified as remote or very remote according to the Accessibility/Remoteness Index of Australia (ARIA) (ABS, 2014).

Most of the Northern Territory has extreme climatic characteristics. The North of the jurisdiction experiences high temperatures and high humidity. The most populous city in the north, Darwin, has an annual mean maximum temperature of 32 degrees and a mean relative humidity of approximately 60 per cent (Australian Bureau of Meteorology, 2014). The North of the jurisdiction is also afflicted with flooding, severe weather episodes, and cyclones. In contrast, the South of the jurisdiction comprises the centre of the continent which in summer is very hot and dry, and in winter can be below freezing. The most populous city in the south, Alice Springs, experiences a mean maximum temperature of

36 degrees in the hottest month of the year (Australian Bureau of Meteorology, 2014). Most of the land mass in the Northern Territory is considered to have below average soil fertility and experiences soil erosion (Smith and Hill 2011), which makes it unsuitable for most forms of agriculture except cattle rearing. A large part of the jurisdiction is covered by rocky terrain and is almost devoid of soil.

3.3.2 Population

This section briefly explores the demographic features of the Northern Territory. The Northern Territory's population characteristics are quite different to the national experience, which has an impact on the economy.

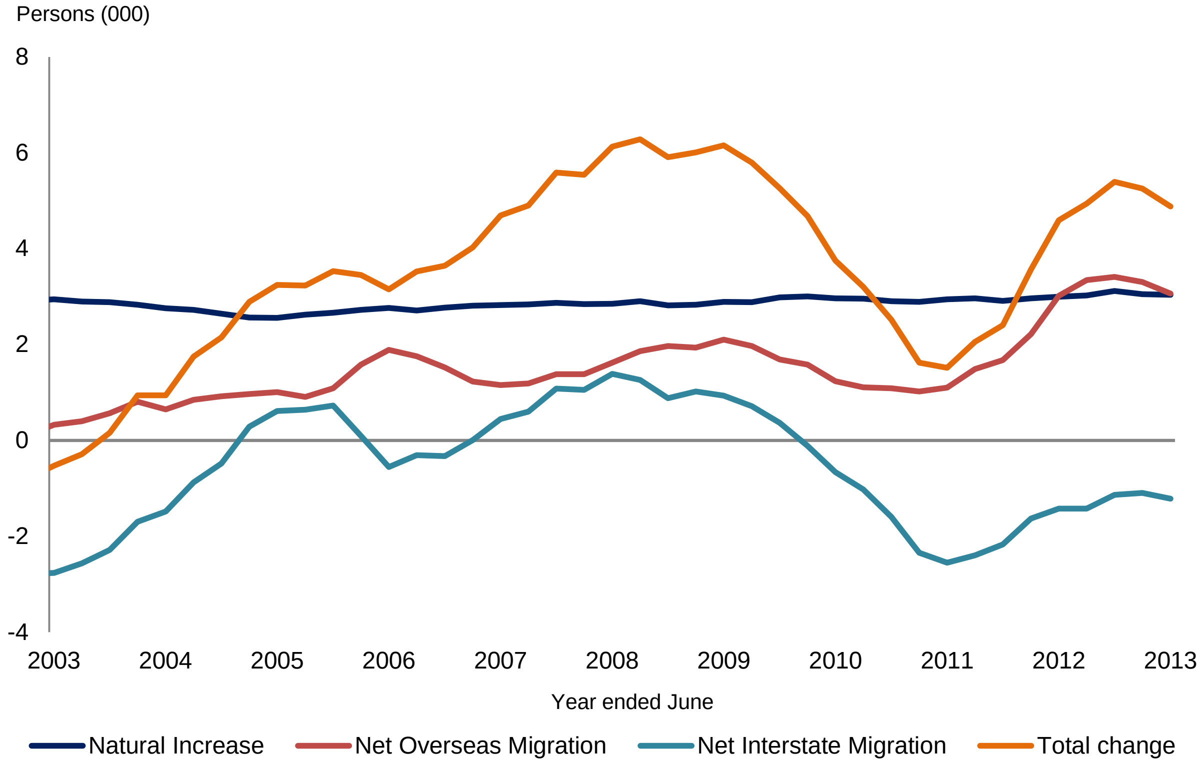
The Northern Territory is marked by its vast land mass and sparse population. The Northern Territory's estimated resident population as at June 2013 was approximately 240,000 people according to the Australian Bureau of Statistics (ABS, Cat. 3218.0). Approximately 135,000 people or more than half of the total population resides in the "greater Darwin" area. Other major population centres include Alice Springs (40,000), Katherine (20,000), Nhulunbuy (4,500) and Tennant Creek (3,500) (ABS, Cat. 3218.0). The rest of the population live in small remote towns or remote communities. The majority of those living in remote communities are Indigenous Australians. Indigenous Australians make up approximately 30 per cent of the total population (approximately 70,000 people), which is the highest proportion of any jurisdiction (ABS, Cat. 3101.0). The Northern Territory's Indigenous population makes up approximately 10 per cent of the total Australian Indigenous population.

The Northern Territory has the youngest population in Australia. Children under the age of 15 make up 22 per cent of the population, which is the highest proportion of any jurisdiction in 2013 (ABS, Cat. 3101). On the other hand, people aged 65 years and over make up 6 per cent of the total population which is by far the lowest proportion of any jurisdiction, with the Australian Capital Territory having the next lowest at 11 per cent. People who fall under the 'working age population' (aged 15-64 years) make up 71 per cent of the Northern Territory's population, which is the highest proportion of any jurisdiction. The Northern Territory also has the highest sex ratio (the number of males per 100 females) of any jurisdiction, with the ratio being 111 in 2013.

Over the last 3 periods the Northern Territory has experienced population growth that is above the Australian average. The majority of this growth is occurring in the greater Darwin area, and is driven by positive net overseas migration that is attributable to increased economic activity. Gerritsen (2010) however suggests that while there is strong population growth in the short run, over the long run the Northern Territory's population growth rate will be slower than the rest of Australia.

In terms of migration patterns, the Northern Territory's net interstate migration has been negative since 2010, while net overseas migration has been overwhelmingly positive, which is similar to the Australian experience with only 9 quarters since 1981 experiencing negative net overseas migration. The natural increase rate is significantly higher than the Australian average rate (1.3 per cent compared to 0.7 per cent over the last 5 periods) (ABS, Cat. 3101.0). The Northern Territory is marked by a high level of population transience, which has implications for the labour market. Figure 3.1 decomposes total change in the Northern Territory's population over the last 10 periods.

Figure 3.1: Change in the Northern Territory's population, 2003 to 2013



Source: ABS, Cat. No. 3101.0, Australian Demographic Statistics

The high degree of mobility in the Northern Territory, particularly in remote regions where seasonal and cyclical mobility is prevalent, is a major factor in creating unpredictability in the economy (Measham et al., 2012). Consequently, human capital utilised for development in the Northern Territory is traditionally sourced externally and arranged temporarily (e.g. fly-in fly-out workers).

3.3.3 Natural resources

Although mining occurs on less than one per cent of the Australian land mass, it contributes significantly to the Northern Territory economy and is the most dominant sector. In 2012-13, mining made up 19.5 per cent of the Northern Territory's total output, compared to

10.5 per cent for Australia (ABS, Cat. 5220.0). The resources sector impacts the Northern Territory economy through trade, investment and generating business activity. In terms of value, the extraction of gas and liquid is the largest extracted resource in the Northern Territory. Other resources extracted include (in order of value): manganese; oil; uranium; gold; zinc; bauxite; and iron ore (Department of Mines and Energy).The resources sector is influenced by changes in commodity prices which are subject to cyclical movements determined by international supply and demand, and foreign exchange rates.

While the resources sector is a significant contributor to the Northern Territory economy, the capital-intensive nature of mining and the non-resident status of a significant proportion of the labour force means that the industry only makes up 3.9 per cent of the Northern Territory's resident employment (Department of Treasury and Finance, 2013). Further, the resources sector typically generates rent outside the Northern Territory as most operating companies are owned by interstate or international entities. It worth noting that like all other jurisdictions in Australia with extractive industries the Northern Territory has a mining royalties regime that is profit-based. Gerritsen (2010) argues that the high level of rents received from resource extraction is not matched by investment in labour or infrastructure in the Northern Territory. The features of the Northern Territory's resources sector are similar to that in the rest of Australia and internationally.

3.3.4 Socio-economic features

As discussed, most of the Northern Territory is classified as remote or very remote under ARIA. ARIA is a continuous index with values ranging from 0 (high accessibility) to 15 (high remoteness). The index is based on road distance measurements from population centres in Australia to the nearest 'service centre'. Service centres are grouped into categories depending on the size of the centre and the services provided. According to the ABS more than 40 per cent of the Northern Territory's population resides in remote or very remote regions (ABS, 2011 Census). No part of the Northern Territory is classified as a "major city" or "inner regional Australia". Darwin, which is the largest city in the Northern Territory, is classified as "outer regional Australia". The impact of remoteness is compounded with accessibility issues. Parts of the Northern Territory, particular the North is inaccessible by road for up to four months of the year due to flooding and the lack of sealed roads. A consequence of remoteness and accessibility issues is reduced access to government and private services; as a result there is unpredictability and lack of control over the market, labour, essential services. and decisions (Larson, 2010).

A large proportion of the Northern Territory's population experiences socio-economic disadvantage. Over 50 per cent of the Northern Territory's population is in the lowest two quintiles of the ABS's 'Socio-Economic Index for Areas', compared to under 40 per cent nationally. The primary reason for this is the Northern Territory's relatively large Indigenous population, with nearly one in three people being Indigenous. Indigenous people are among the most disadvantaged communities in Australia in terms of health, education, and economic participation outcomes. Australia's Indigenous population uses significantly more government services per capita than the non-Indigenous population, with the differential being even greater for remote Indigenous people who experience a greater degree of disadvantage. A range of statistics can be used to highlight the difference, in the Northern Territory Indigenous people: are over three times more likely to be imprisoned (ABS, Cat. 4512.0); are over five times more likely to have a hospital 'separation' (AIHW, 2014); have child mortality rates over three times higher than the non-Indigenous population (AIHW, 2011); and are significantly less likely to achieve the national minimum standard for reading, writing and numeracy (NAPLAN, 2013). In 2010-11, the Northern Territory spent $2.5 billion on services related to Indigenous people, which represents over 55 per cent of general government expenditure. In comparison, Indigenous people represent 30 per cent of the Northern Territory's total population. This difference is indicative of the high level of needs arising from the Indigenous population and how it impacts government services (Productivity Commission, 2012).

Larson (2010) considers that many remote regions in the Northern Territory are not just limited by the lack of financial capital, but also have limited built capital and low levels of human and social capital. Larson continues that human and social capital have an integral role in determining how society progresses. In this light, the Northern Territory public sector plays a major role in the provision of employment in the Northern Territory and generating human and social capital in regional areas where it is not viable for other entities to do so. The public sector is the largest employer in the Northern Territory employing over 35 per cent of the total work force (ABS, Cat. 6202.0).

3.3.5 Inter-governmental relations

Compared to other jurisdictions, the Northern Territory is heavily dependent on Commonwealth Government financial assistance to deliver basic services. Close to 70 per cent of the Northern Territory's revenue comes from the Commonwealth Government in the form of tied grants and GST revenue, while the other 30 per cent comes from own source revenue (Department of Treasury and Finance, 2014); in comparison, for other jurisdictions funding from the Commonwealth Government makes up on average

45 per cent of total revenue (Commonwealth Grants Commission, 2014). GST revenue makes up 50 per cent of total revenue and is the largest revenue transfer from the Commonwealth Government to the Northern Territory. The distribution of GST between States and Territories is determined by the Commonwealth Grants Commission (CGC) which recommends the distribution based on the principle of 'horizontal fiscal equalisation' and formulated through a complex methodology which assesses each states fiscal capacity relative to the average. Changes to this methodology and key socio-demographic drivers pose a significant risk to the Northern Territory's fiscal capacity. For instance, in the 2014 Update the CGC incorporated 2014 Census data in the methodology which reduced the Northern Territory's share of the national Indigenous population; this change alone effectively reduced the Northern Territory's GST distribution by over $100 million. As a consequence of this risk, the Northern Territory government does not have the same level of fiscal autonomy and control compared to other sub-national governments, which affects planning and service delivery.

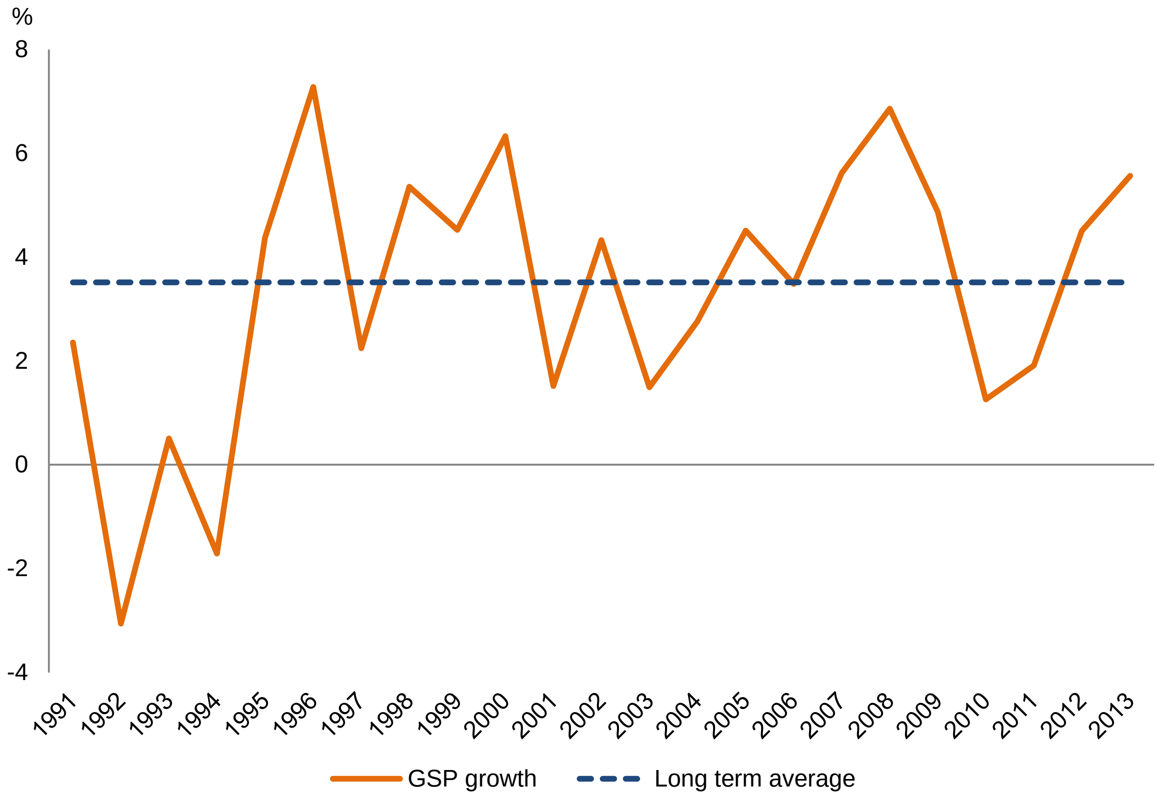
3.4 Economic performance and trend analysis

This section presents a study of the Northern Territory's economic performance between 1990 and 2013 through a trend analysis of key economic indicators. The purpose of this is to highlight patterns in the economy and explore the drivers. This section includes analysis on output and its components, the labour stock and employment, and the capital stock.

3.4.1 Output

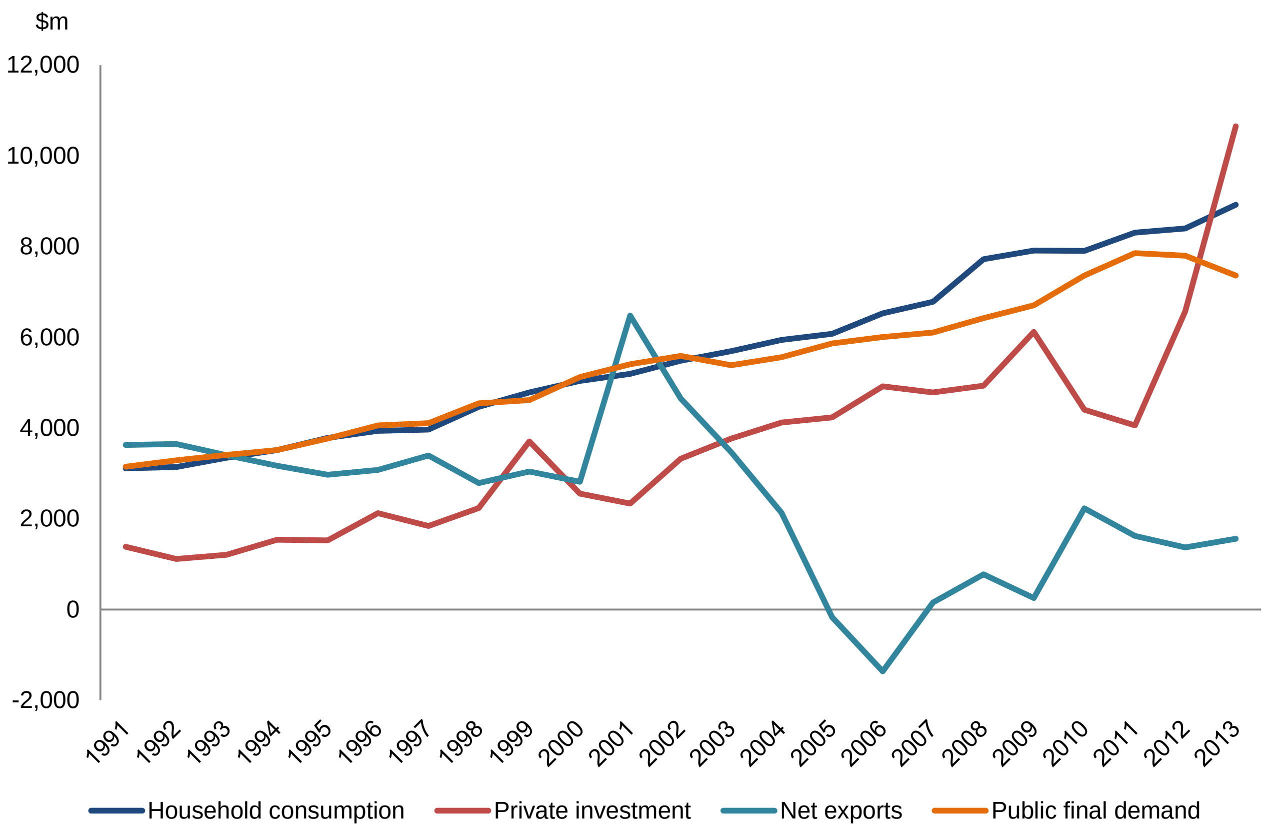
Figure 3.2 shows the growth in Gross State Product (GSP), while Figure 3.3 decomposes GSP into different components.

Figure 3.2: GSP growth, Northern Territory, 1991 to 2013



Source: ABS 2013, Cat. No. 5220.0, State Accounts

Figure 3.3: Components of GSP, Northern Territory, 1991-2013



Source: ABS 2013, Cat. No. 5220.0, State Accounts

Figure 3.2 shows that over the sample period average output growth was 3.3 per cent per year, which is marginally higher than the Australian average (3.1 per cent). Over the last 10 periods average output growth was stronger at 3.9 per cent, which is again higher than the national average (3.0 per cent). Figure 3.3 shows over the sample period household consumption and public final demand have grown consistently, while private investment has fluctuated but has been a major influence on GSP.

Between 1991 and 1992 the Northern Territory experienced a recession with GSP declining by 3.1 per cent. This is considered to be the lagged impact of the national recession, which resulted in GDP contracting by 1.4 per cent between September 1990 and September 1991

(ABS, Cat. 5204.0). This period was marked by high inflation and high unemployment (stagflation) followed by a sharp decline in residential property prices (Lowe and Gizycki, 2000). During this period there were no significant changes to household consumption or public demand, however there was a 20 per cent decline in private investment in the Northern Territory. After the recession, growth in the Northern Territory's GSP experienced five peaks and three minor troughs over the sample period.

The first peak was between 1995 and 1996 when GSP grew by 7.3 per cent, this was primarily driven by the resources sector which increased output by 24 per cent, and private investment which increased by 39 per cent. During this period other sectors that contributed to growth were agriculture, manufacturing and public administration; the telecommunications sector grew by 15 per cent although it only made up one per cent of total output.

The second peak was between 1997 and 1998 when GSP grew by 5.4 per cent, again this was primarily driven by the resources sector which increased output by 10.8 per cent, and the construction sector which increased output by 13.1 per cent. Together these two sectors made up over half of total output growth. During this period the public sector also experienced strong growth which is observable in an 11 per cent increase in public final demand.

The third peak was between 1999 and 2000 when GSP grew by 6.3 per cent, again this was primarily driven by the resources sector which increased output by 57 per cent or approximately $850 million. The resources sector made up over 85 per cent of total output growth. This was primarily due to the commencement of production at the Laminaria-

Corallina oilfields. It is observed that in the prior period there was a 66 per cent increase in private investment which is attributable to population growth and the defence relocation program which stimulated construction and business activity (Department of Treasury and Finance, 2001).

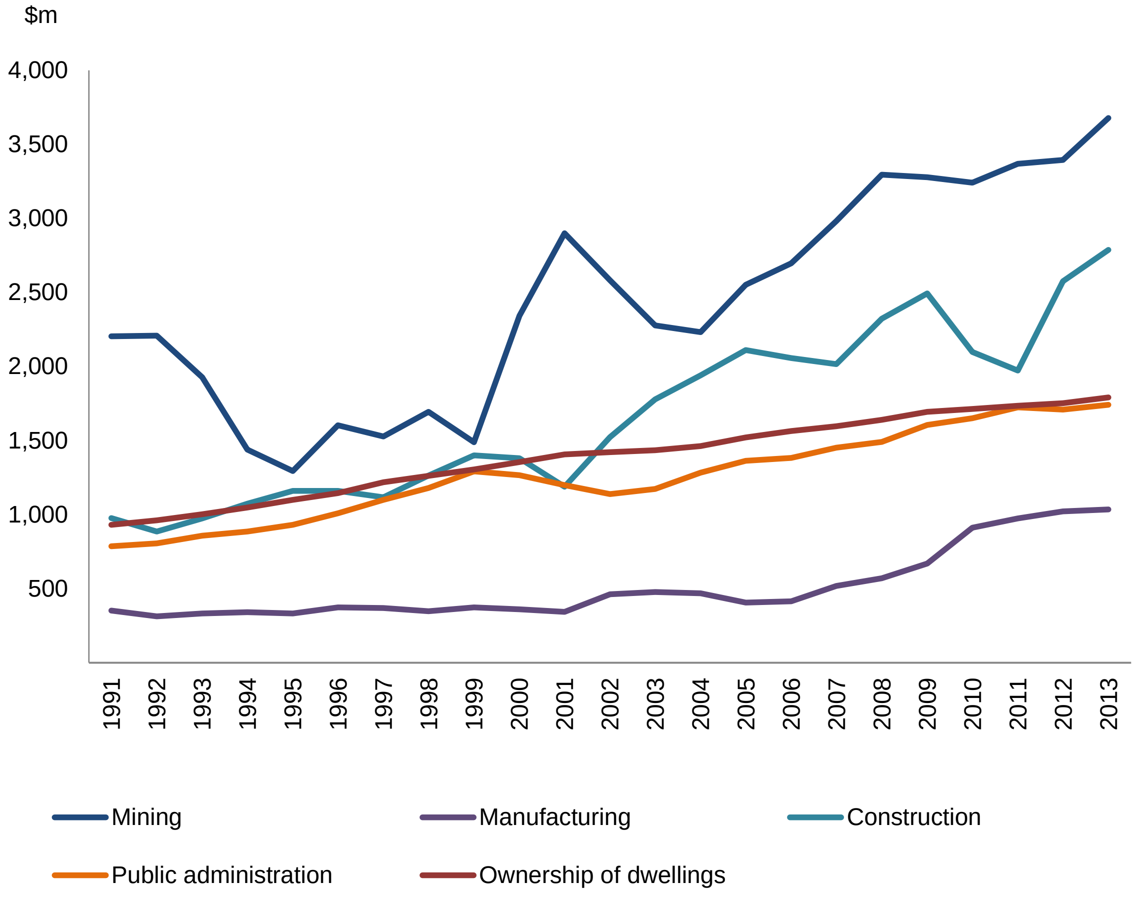
The fourth peak was between 2007 and 2008 when GSP grew by 6.9 per cent, this was driven by growth in the resources and construction sectors, which together made up 60 per cent of total output growth. Other sectors that experienced strong output growth include finance and insurance services, agriculture, and manufacturing. During this period net exports increased by over 400 per cent which is attributable to the substantial increase in demand for mineral ores, particularly alumina, manganese, lead-zinc concentrate, and uranium (Department of Treasury and Finance, 2008).

The fifth peak was between 2012 and 2013 when GSP grew by 5.6 per cent, this again was driven by growth in the resources and construction sectors which together made up 57 per cent of total output growth. This is also observable in a record 162 per cent increase in private investment between 2011 and 2013, which is mostly attributable to the $60 billion INPEX Ichthys gas project which started construction during this period (Department of Treasury and Finance, 2013). Other sectors that experienced strong growth include health due to strong population growth and the need for more services, and transport due to a significant increase in demand for haulage for construction.

The analysis above indicates that the Northern Territory economy is driven by private investment in the resource and construction sectors, which combined make up over 30 per cent of total output growth over the sample period. This is disproportionate compared to what is experienced on a national level, were just under 15 per cent of total output was generated by the resource and construction sectors combined (ABS, Cat. 5220.0).

Figure 3.4 and Table 3.1 decompose GSP growth into key sectors, namely: mining, manufacturing, construction, public administration, and ownership of dwellings.

Figure 3.4: Decomposition of GSP by key sectors, Northern Territory, 1991-2013



Source: ABS 2013, Cat. No. 5220.0, State Accounts

Table 3.1: Decomposition of GSP by key sectors, Northern Territory, 1991-2013

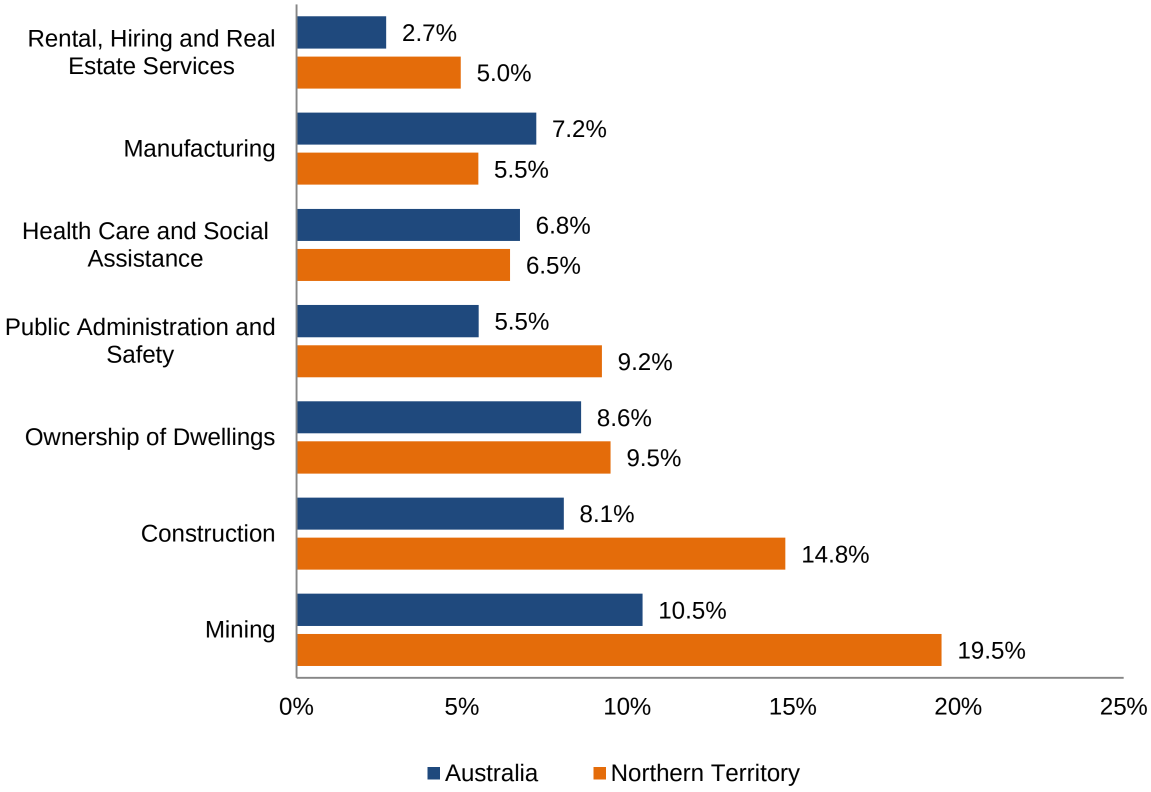
	GSP	Mining	Construction	Ownership of dwellings	Public administration and safety
Average growth	3.4%	3.6%	5.5%	3.0%	3.8%
Average growth last 10 periods	4.1%	5.0%	5.3%	2.2%	4.1%
Share 1990	100%	23%	10%	10%	8%
Share 2013	100%	19%	14%	9%	9%

Source: ABS 2013, Cat. No. 5220.0, State Accounts
Notes: growth in chain volume measure, share in current prices.

Figure 3.4 and Table 3.1 show that the resources sector is the largest component of the economy and for this reason drives growth in GSP. Over the last 10 periods, output growth in the resources sector averaged 5.0 per cent, which is higher than its long term average of 3.6 per cent. However as a share of total output the resources sector has declined between 1990 and 2013 due to other sectors growing relatively faster over the last 10 periods including: professional, scientific and technical services (10.53 per cent growth); manufacturing (8.87 per cent); rental, hiring and real estate services (8.32 per cent); healthcare (6.34 per cent), and construction (5.28 per cent).

Figure 3.4 shows that both the resource and construction sectors experience strong upswings and downswings, when compared to other large components such as the public administration, health, and education sectors. This is due to the nature of mining and construction industries which are project-based and rely on substantial amounts of private investment, which can make output in these sectors "clumpy" (Syed, et al. 2013). In contrast, the other large sectors noted are driven by public investment and demand for recurring services, and as such do not experience substantial fluctuations year to year. This is also noticeable in Figure 3.3 which shows that public final demand has grown consistently over the sample period, while private investment has fluctuated more. Figure 3.5 shows the output of key sectors as a proportion of the Northern Territory's GSP, compared with the same sectors as a proportion of national GDP.

Figure 3.5: Comparison of key sectors as a proportion of GSP and GDP, 2012-13.



Source: ABS 2013, Cat. No. 5220.0, State Accounts
Notes: growth in chain volume measure, share in current prices.

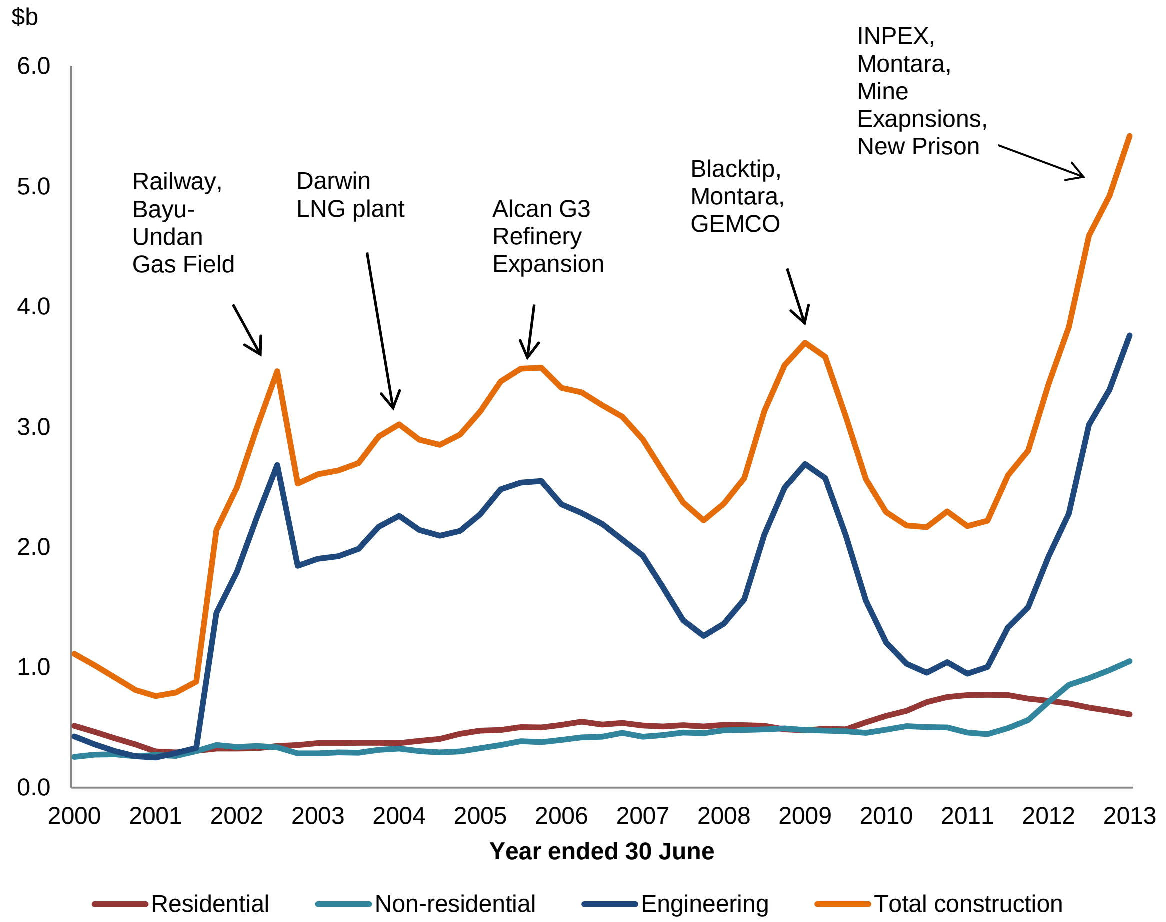
Figure 3.5 highlights that the three stand-out sectors in the Northern Territory economy are: the mining; construction; and public administration sectors.

As a proportion of GSP, the resources sector is the largest and makes up 19 per cent of total output. Nationally mining only makes up 10.5 per cent of output which is due to some jurisdictions having relatively small or non-existent mining sectors such as Victoria, Tasmania and the Australian Capital Territory, and the strength of other sectors that are relatively smaller in the Northern Territory such as finance and insurance services, and science and technical services. Compared to jurisdictions with larger resources sectors, the Northern Territory's resources sector makes up the highest proportion of output after Western Australia (34.3 per cent of output), followed by Queensland (10.2 per cent), South Australia (4.1 per cent), and New South Wales (3.1 per cent).

After the resources sector, construction makes up the largest proportion of GSP at 16 per cent of total output; nationally, construction only makes up around 8 per cent of GDP. Historically, the construction sector has been closely tied to the resources sector. The growth in construction activity since 2011 reflects ongoing activity with major resource projects, such as the establishment of the INPEX Ichthys project, development of the Montara oilfield, and expansion of existing mining projects (Department of Treasury and Finance, 2013). Figure 3.6 breaks down construction work in the Northern Territory and shows that construction is driven by engineering work which is associated with major resource projects. Residential and non-residential construction has also increased in association with developments in the resources sector, particularly construction of accommodation facilities and the establishment of new suburbs in response to population growth. Over the last ten years residential construction made up 20 per cent of total construction activity (ABS, Cat. 8755.0).

Figure 3.6 shows a decomposition of construction work done in the Northern Territory since 2000 and notes when major projects occurred.

Figure 3.6: Construction work done, Northern Territory, 2000-2013



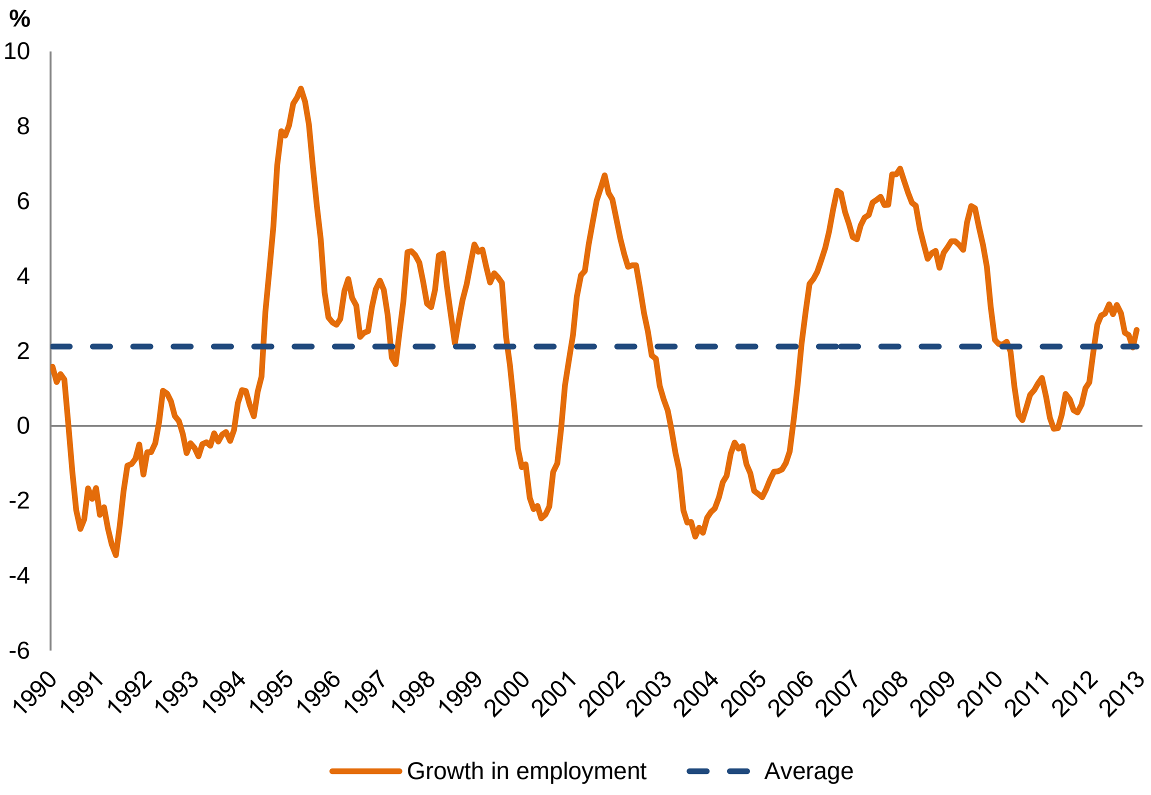
Source (data): ABS 2013, Cat. No. 8755.0, Construction Work Done
Source (labels): Northern Territory Treasury, 2014-15 Budget
Notes: Inflation adjusted

Public administration and safety, and health care and social services both increased as proportion of GSP since 2007, which marked the start of the "Northern Territory Intervention" (now called the "Stronger Futures" program), which saw an increase in Commonwealth funding towards services aimed at improving outcomes for Indigenous people. Public administration makes up 9.2 per cent of output in the Northern Territory, which is above the national average of 5.5 per cent and the highest of all jurisdictions after the Australian Capital Territory (29 per cent) which contains the majority of the Commonwealth public service, followed by Tasmania (6.8 per cent) and South Australia (5.8 per cent).

3.4.2 Employment

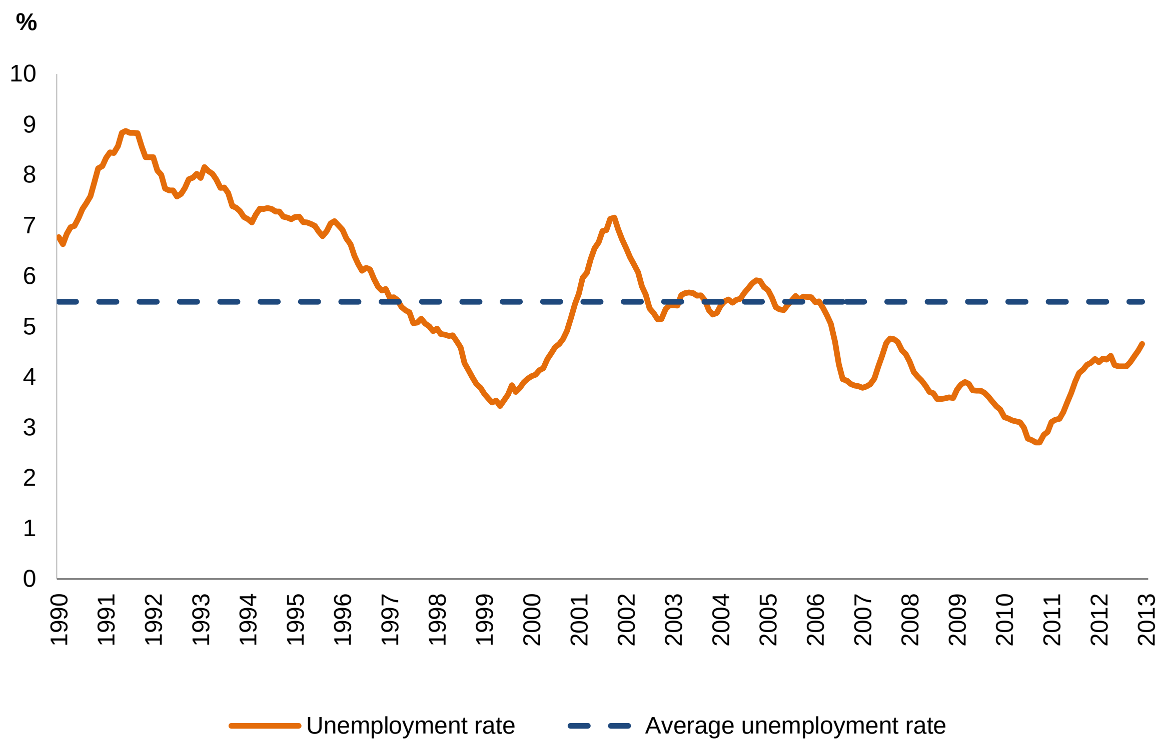
Figure 3.7 shows annual growth in employment, and figure 3.8 shows the annual average unemployment rate over the sample period.

Figure 3.7: Annual growth in employment, Northern Territory, 1990-2013



Source: ABS 2013, Cat. No. 6202.0, Labour Force Australia

Figure 3.8: Unemployment rate, Northern Territory, 1990-2013



Source: ABS 2013, Cat. No. 6202.0, Labour Force Australia

Figure 3.7 shows that the average annual growth in employment over the sample period was 2.1 per cent, while Figure 3.8 shows that the average unemployment rate over the sample period was 5.5 per cent. Comparing these measures, employment growth was more volatile over the sample period.

In the 1991 calendar year the Northern Territory experienced negative employment growth, which was close to -2.5 per cent, followed by a period of above average unemployment until 1993. This is associated with Australian recession and decline in output. At the same time the labour force was shrinking which effectively understates the level of unemployment experienced in the Northern Territory during this period.

Between 1995 and 1996 employment growth peaked at 9 per cent which corresponds with substantial output growth over the same period (Figure 3.2). This was driven by employment growth in sectors that represent a large proportion of the total workforce, such as the construction, health services, and retail sectors. This is associated with population growth arising from the defence force relocation to the North of the jurisdiction (Department of Treasury and Finance, 1996).

Between mid 2000 and early 2001 employment growth was negative again and averaged close to -2.0 per cent, this was associated with below average output growth and decline in employment in the primary and secondary industries such as the agriculture, mining, construction and manufacturing sectors. However, towards the end of 2001 employment picked up and peaked around 6.7 per cent in early 2002. This time employment growth did not correspond with output growth. The main driver for employment growth during this period was the public administration and health sectors, which together increased employment by over 20 per cent and comprised over 20 per cent of the total work force. This is associated with the election of a new government in 2001, which saw an immediate expansion in public services. Interestingly, at the same time unemployment peaked at 7.1 per cent which is attributed to above average growth in the labour force and participation rate. This indicates that while employment growth was strong in certain sectors, it could not keep up with the overall expansion of the labour force.

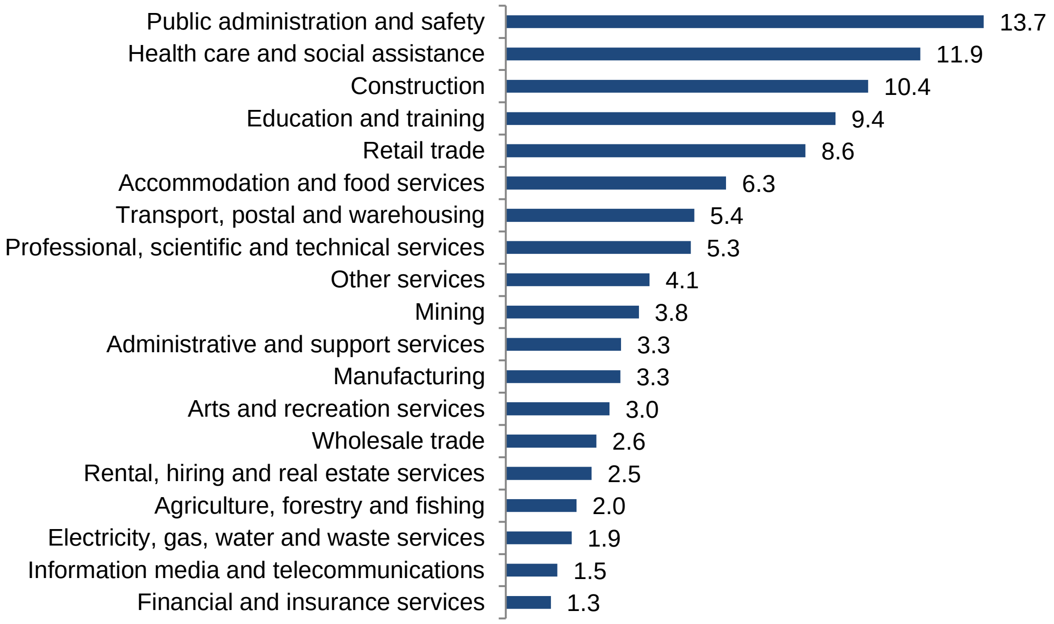
Between the end of 2003 and 2004 employment growth was negative and averaged around -2.0 per cent, which is associated with a decline in output, public final demand, and employment in sectors such as the agriculture, manufacturing, and transport sectors.

Between 2007 and 2010 employment growth peaked at 9 per cent. This was driven by employment in the public administration, health, and education sectors and associated with the introduction of the “Northern Territory Intervention” and the expansion of government services. Additionally an increase in construction activity associated with resources projects such as the Blacktip onshore gas facility, the Montara oilfields project, and the GEMCO manganese refinery, was also a stimulus for employment (Department of Treasury and Finance, 2008).

Comparing the last 10 periods with the entire sample period, employment growth has been stronger (3.1 per cent compared to 2.1 per cent) and the unemployment rate has been weaker (4.4 per cent compared to 5.5 per cent), which is mostly attributable to larger investments in the resources sector and the expansion of the public service over the last 10 periods which has also benefitted other sectors in the Northern Territory economy.

Figure 3.9 illustrates each sectors share of total employment in the Northern Territory.

Figure 3.9: Employment per sector as proportion of total employment, Northern Territory, 2012-13, per cent



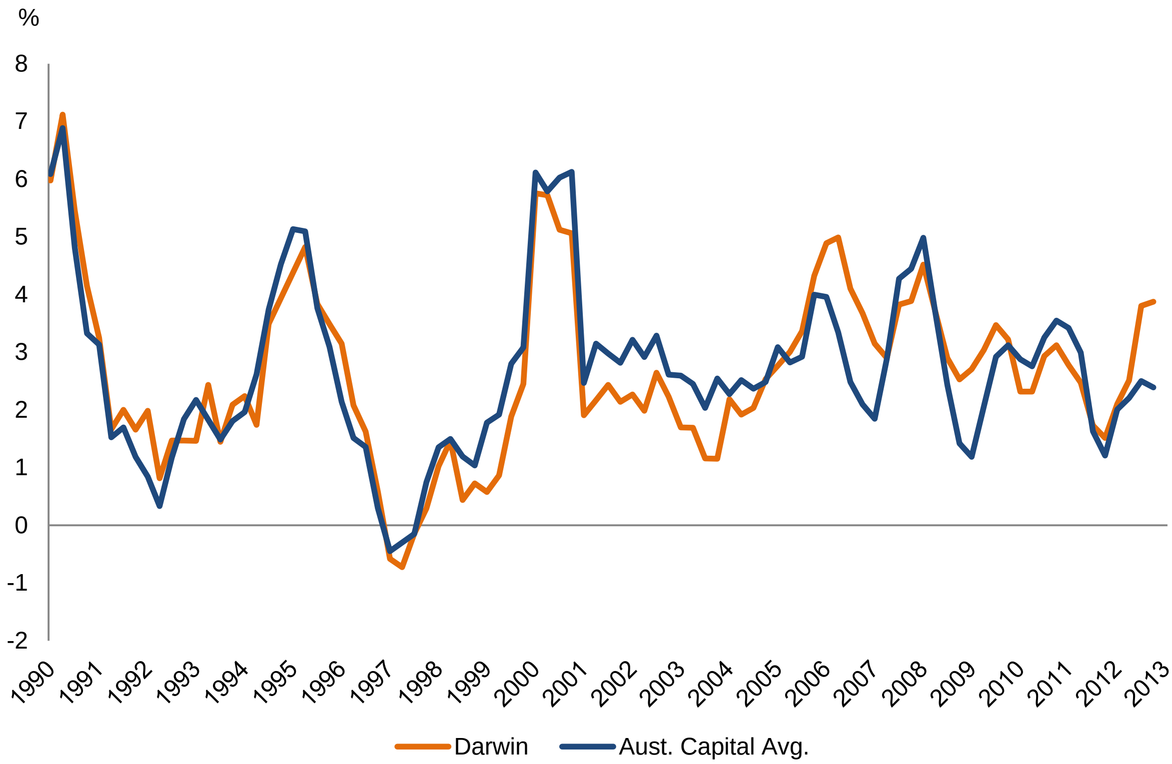
Source: ABS 2013, Cat. No. 6291.0.55.003, Labour Force Australia
Notes: Figures in percentage terms

Figure 3.9 shows that employment in the public administration, health, and education sectors together make up 35 per cent of employment in the Northern Territory, which is greater than the combined output for these sectors which is around 20 per cent of total output. Nationally these sectors make up around 25 per cent of employment. The difference arises from the Northern Territory's unique demography (discussed in section 3.3) which requires an above average level of public services, and the relatively small size of other service sectors which makes the public sector larger as a proportion. The other stand out difference between employment and output is the resources sector, which only employs 3.8 per cent of the total workforce, however makes up 19 per cent of total output. This ratio is consistent across Australia and is the result of the resources sector being more "capital intensive" rather than "labour intensive" (Tropp et al., 2008).

3.4.3 Prices

Figure 3.10 compares the inflation rate in Darwin compared to the Australian state capital average between 1990 and 2013.

Figure 3.10: Inflation rate, Darwin and Australian capital average, 1990-2013



Source: ABS 2013, Cat No. 6401.0, Consumer Price Index

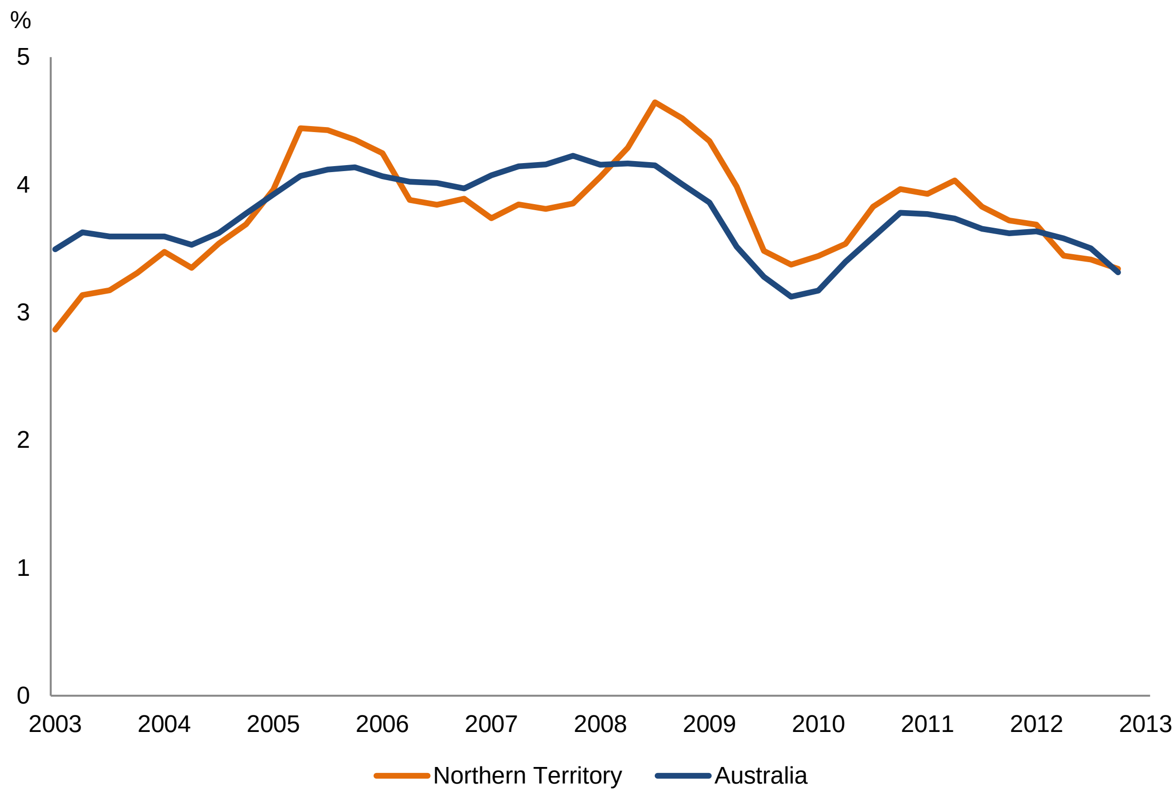
Figure 3.10 shows that over the sample period, the inflation rate for Darwin has largely corresponded with the Australian capital average inflation rate. The ABS measures inflation through the Consumer Price Index which includes different goods and services with different weights depending on their importance. For Darwin, goods and services associated with recreation and culture, alcohol and tobacco, and health services experienced the highest average inflation over the sample period, which is consistent with the Australian capital average. There were two periods where inflation in Darwin was substantially higher than the Australian capital average: between 2006 and 2007, higher inflation was attributable to increased house costs, particularly purchase costs, which reflects a strong housing market and also increased food costs which reflect national supply constraints following Cyclone Larry; and between 2012 and 2013, higher inflation was attributable to increases in utility prices and motor vehicle registrations, and the impact of the carbon tax, all of which are a result of government measures (Department of Treasury and Finance, 2013).

It is important to note that the inflation rate only measures the change in prices over a given period of time. This does not measure the cost of living, which in the Northern Territory is higher than the national average and in some respects the highest in Australia (NT Council of Social Services, 2014). Two factors that result in higher prices in the Northern Territory, is the small size of the economy which makes it harder to achieve economies of scale, and the cost of transport. For example, establishing a health clinic requires a certain minimum level of staff, equipment and administration regardless of where one is; however in many locations across the Northern Territory these health clinics service a small population, which means that these minimum costs are spread across less people. Similarly, the cost of transport is also spread across fewer people, which impacts the cost of living given that the Northern Territory imports a greater proportion of goods compared to other jurisdictions.

3.4.4 Cost of labour

Figure 3.11 compares the year on year growth of the Wage Price Index (WPI) between the Northern Territory and Australia, over the last 10 periods.

Figure 3.11: Wage price index, Northern Territory and Australia, 2003-2013



Source: ABS 2013, Cat. No. 6345.0. Wage Price Index

The WPI measures changes in the price employers pay for a standard unit of labour that arise from market factors. Wages growth in the Northern Territory can be volatile which reflects the impact major projects have on the supply and demand of labour in small economies. Wages growth in the Northern Territory has largely followed the Australian average trend. Between 2005 and 2006 there was a peak in wages growth which is attributable to a national skills shortage, particularly in sectors such as mining and construction (Taylor and Bell, 2012). In this period the difference between wages growth in the Northern Territory and the Australian average was an enterprise bargaining outcome, which led to wages growth for those employed in the Northern Territory's public service. Another peak in wages growth was experienced in 2009, attributable to a number of major projects in the resources sector (see Figure 3.6); however, wage growth moderated after the completion of these projects and an overall slowdown in the Northern Territory economy.

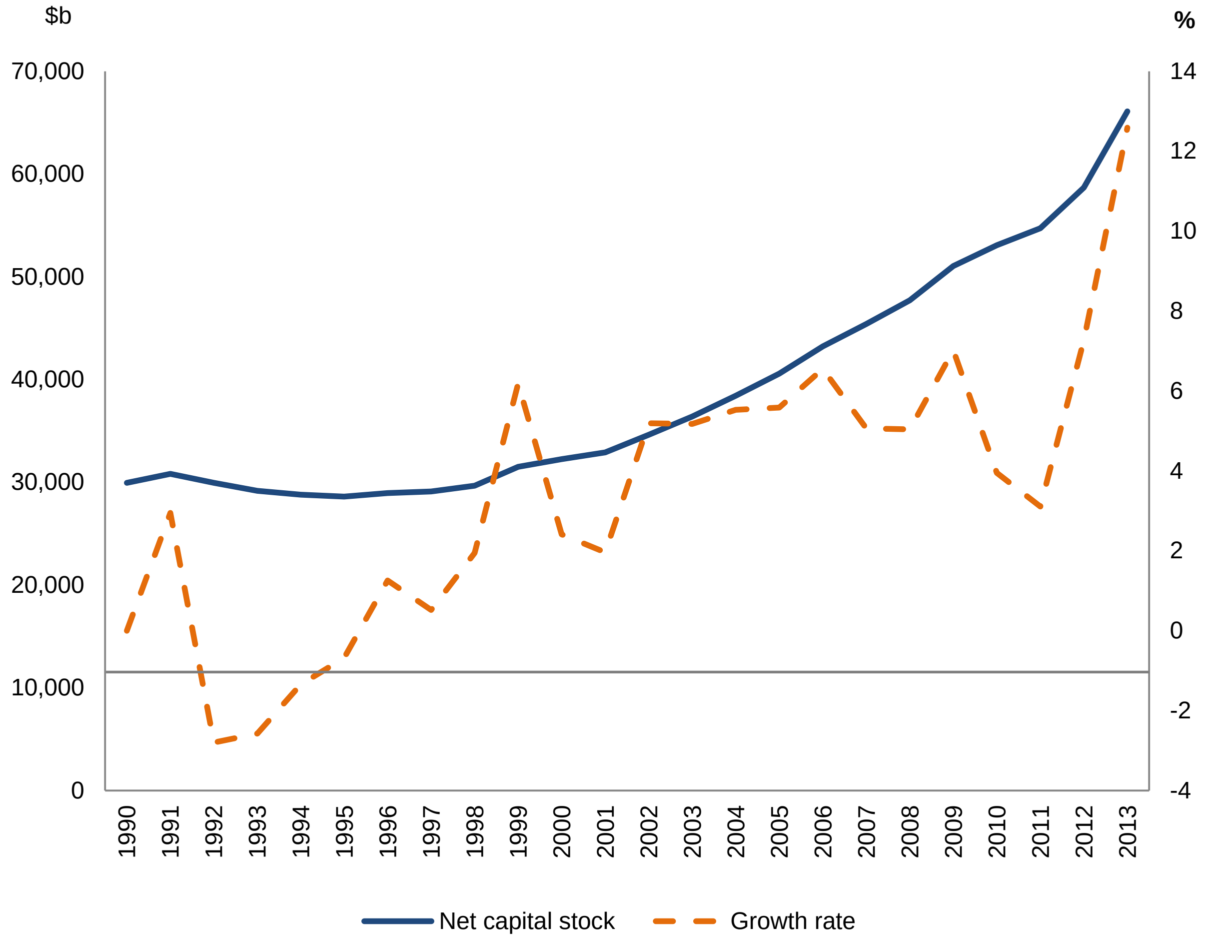
The cost of labour in the Northern Territory is influenced by a number of factors. Firstly, the cost of living in the Northern Territory is higher than average which places upward pressure on the cost or labour, secondly the relatively small size of the labour market increases competition which again places upward pressure on wages, and thirdly higher than average wages are offered to encourage interstate labour migration. These pressures on the cost of labour are further exasperated by large resource projects that increase the demand for labour and create supply constraints in the labour market. One outcome of this dynamic is the utilisation of fly-in fly-out workers in the Northern Territory, who make up 5.2 per cent of the total work force, the largest proportion of any jurisdiction (Brokensha, et. al 2013).

3.4.5 Capital stock

Figure 3.12 shows the evolution of net capital stock between 1990 to 2013 in the Northern Territory. The method of calculating net capital stock for the Northern Territory is described in Chapter 4.

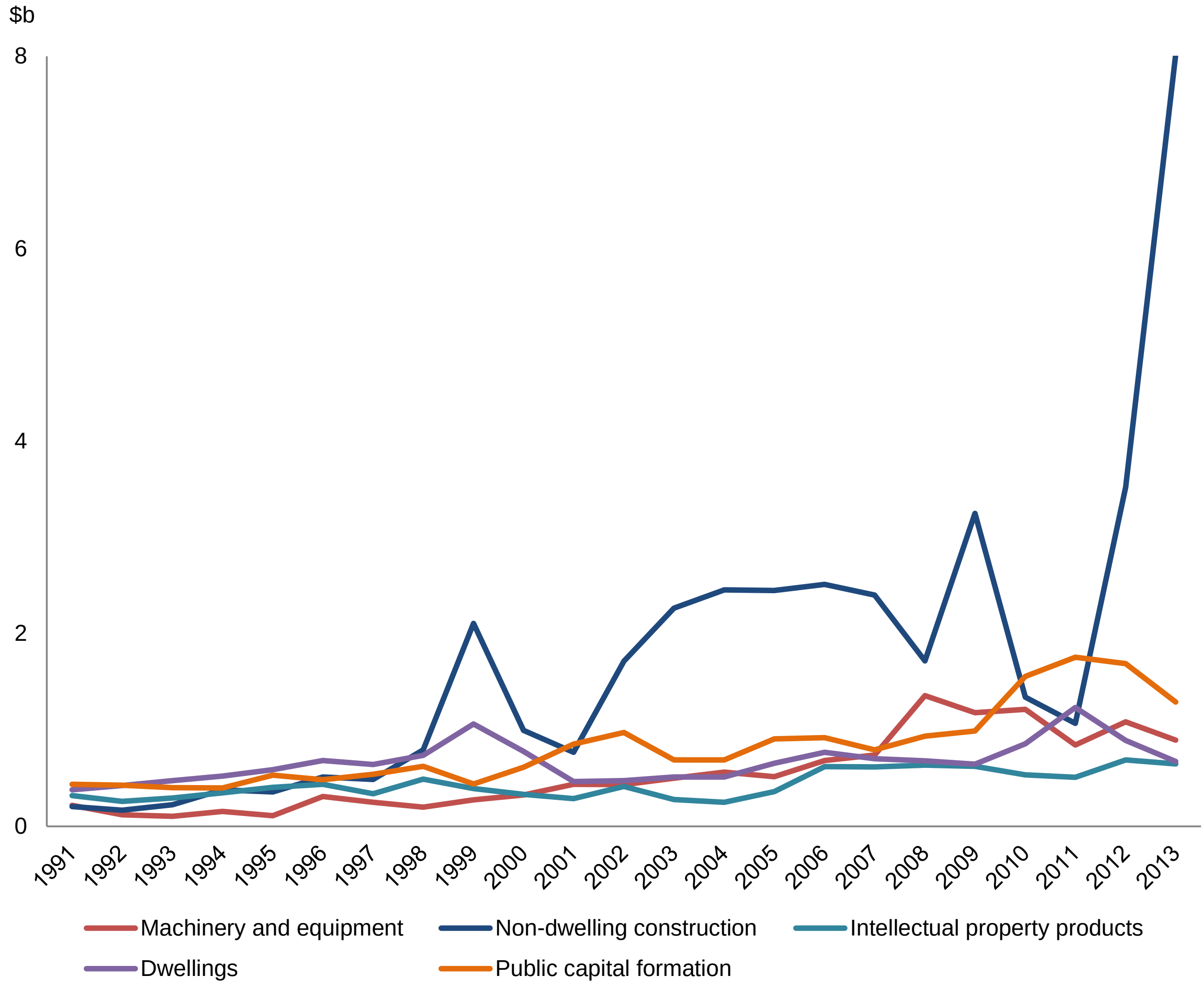
Figure 3.13 shows the components of the Gross Fixed Capital Formation in the Northern Territory.

Figure 3.12: Evolution of net capital stock, Northern Territory, 1990-2013



Notes: The data and methodology used to calculate net capital stock is discussed in Section 4.2.2.

Figure 3.13: Decomposition of Gross Fixed Capital Formation, Northern Territory, 1991-2013



Source: ABS 2013, Cat. No. 5206.0, Australian National Accounts

Net capital stock grew on average 3.6 per cent over the sample period and experienced frequent fluctuations. Figure 3.12 shows that there have been three peaks in growth over the sample period, while Figure 3.13 shows that these peaks correlate with substantial increases in non-dwelling construction, which represents the construction of industrial and commercial assets, which in the Northern Territory is driven by major resource projects.

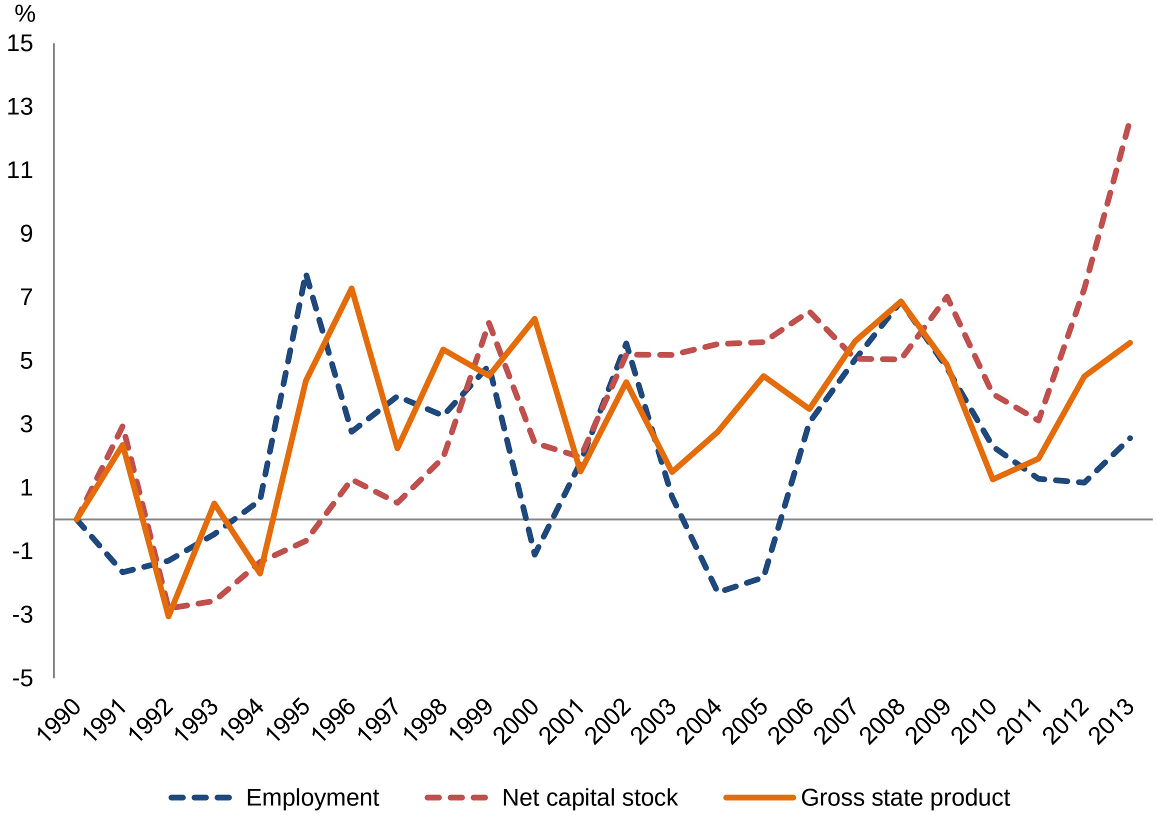
Over the last two periods net capital stock has increased on average by 9.9 per cent per year. This is driven by growth in fixed capital formation in non-dwelling construction, which increased on average by 180 per cent per year. This is mostly attributable to the INPEX Ichthys project starting construction. Prior to this period fixed capital formation in non-dwelling construction was declining due to resource projects finishing capital works and making a transition into the production phase. However, during this period there were substantial increases in fixed capital formation of public capital and dwellings.

It is also worth highlighting that during and after the Australia recession, the Northern Territory's net capital stock declined on average by 2.7 per cent per year. This was primarily the result of a decline in private investment, which impacted the fixed capital formation of machinery and equipment, while there was also significant declines in the formation of public capital. Both the Northern Territory government and the private sector only started to increase fixed capital formation between 1995 and 1996. This is consistent with the Australian experience.

3.4.6 Observations

This section provides a summary of the trend analysis presented in the chapter. Figure 3.14 shows the evolution of output, employment and net capital stock in one graph. Table 3.2 shows the correlation between output and the factors of production.

Figure 3.14: Growth in GSP, employment and net capital stock, Northern Territory, 1990-2013



Source: ABS 2013: Cat. No. 5206.0, Australian National Accounts; Cat. No. 6202.0, Labour Force Australia

Table 3.2: Correlation between growth in output, employment and net capital stock, Northern Territory,

	Sample period	***Last 5 periods***
	Output	**Output**
Employment	0.4811984	0.3898600
Net capital stock	0.5637665	0.8768760
Factor correlation	0.2669309	0.2435856

Source: ABS 2013: Cat. No. 5206.0, Australian National Accounts; Cat. No. 6202.0, Labour Force Australia

Figure 3.14 and Table 3.2 show a positive correlation between the two factors (employment and capital) and output. The correlation between output and capital is stronger, reflecting the impact of the resources sector on the Northern Territory economy; correlation is significantly stronger over the last 5 periods, which is attributable to an expansion of mining activity in the Northern Territory. In contrast, the correlation between output and employment is weaker, with output growth lagging behind employment growth in the first half of the sample period and the opposite occurring in the second half of the sample period. It can also be observed that the correlation between the two factors of production is quite weak. This reflects the nature of the various sectors in the Northern Territory, with the resources sector being capital intensive and the public sector being labour intensive. Strong growth in either of these sectors would see strong growth in one factor that is disproportionate to growth in the other factor. Figure 3.14 highlights that growth in all three measures are quite volatile, with output growth being relatively smoother than the factors which is consistent with the Australian experience.

From the analysis in this section it can be observed that the Northern Territory exhibits all the hallmarks of a small developing economy, with economic growth being driven by investment in primary and secondary industries, the presence of a large public sector, and a small services sector. The analysis shows that large resource projects have a significant impact on the economy. These projects drive growth in capital and labour accumulation. However, resource projects are inherently volatile, as a consequence the Northern Territory economy experiences greater fluctuations than other jurisdictions in Australia.

Other major drivers of the economy are the public sector and the tourism sector, which both employ a significant proportion of the total workforce. However, both these sectors are affected by particular factors; the public sector is influenced by government policy which impacts the size of the public service, and the tourism industry is influenced by exchange rates and the cost of travel.

The agriculture, forestry and fisheries, tourism and retail sectors all make a relatively small contribution to the Northern Territory’s output; however, they are vital sectors to the economy in terms of generating economic activity and employment in regional areas (Department of Treasury and Finance, 2013).

Chapter 4 Empirical Analysis

4.1 Introduction

This chapter presents the empirical analysis of the Solow (1956) growth model which was introduced in Chapter 2. Section 4.2 provides an outline of the data sources that are used in the model and any refinements that are required. Section 4.3 presents the application of the Solow growth model to the Northern Territory economy and the interpretation of the results. Finally, section 4.4 considers the limitations of the model and the data.

4.2 Data Sources

The estimation of the Solow (1956) growth model requires values for output, capital input, labour input and an estimate for income shares. Table 4.1 summarises the data that is used, followed by a brief discussion on the characteristics of the data.

Table 4.1: Summary of data sources for inputs for the Solow growth model

Data	Source	Period covered; frequency	Indexation
Output	Gross State Product (ABS State Accounts)	1990-2013; annually	Chain volume
Capital	Gross Fixed Capital Formation and Australian Net Capital Stock (ABS National and State accounts)	1990-2013; annually	Chain volume
Labour	Labour Force Survey (ABS)	1978-2013; monthly or quarterly	Original
Income shares	Estimates of Industry Multifactor Productivity (ABS)	1995-2013; annual	Averaged

4.2.1 Output

Gross State Product (GSP) has been selected as the proxy for output. GSP is considered the state equivalent of Gross Domestic Product (GDP), which is a national level estimate of output. Conceptually there is no difference between GSP and GDP in Australia, except that one measures output at state level and one at national level (ABS, Cat. 5216.0). Some data related differences are explored further in Section 4.4.3.

Solow (1957) uses Gross National Product (GNP) as a proxy for output in estimating technological progress for the United States. The main difference between GNP and GDP is as follows: GNP measures the value of all goods and services produced by citizens of a country either internally or externally, while GDP measures the value of all goods and services produced internally in a given year (ABS, Cat. 5216.0). The use of GDP as a proxy for output is in accordance with recent influential papers that estimate technological progress such as Young (1994), Mankiw et al. (1992), and Barro (1991).

GSP data is reported in chain volume and current prices on an annual basis. The ABS considers that annually linked and reweighted volume measures provide better indicators of movement in real output and expenditure than constant price estimates. This is because unlike constant price estimates, chain volume measures account for changes to price relativities that occur from one year to the next. For these reasons, this thesis will use chain volume GSP data.

The chain volume measures of GSP presented in the Australian National Accounts publication are derived using the Laspeyres formula, which uses a fixed weight for the base period. The ABS revaluates the current price income based estimates of GSP using deflators which are compiled using the available data on the composition of expenditure on state production and movements in associated prices (ABS, Cat. 5216.0). It is important to note that chain volume measures are generally not additive. In order to minimise this impact, the ABS uses the latest base year as the reference year.

4.2.2 Capital

At a national level, the Australian National Accounts produced by the ABS contains a number of capital stock estimates. The measures of capital stock are: gross; net; and productive. Net capital stock is the written down value of an economy's gross capital stock. This is the accumulation of past investment flows, less retirements, and less accumulated capital consumption on the same items (i.e. depreciation). The difference between gross and net capital stock is depreciation. If using national data, net capital stock would be the best proxy for capital as it measures total capital that is available to be utilised for production and is most aligned with Solow's own work.

At a state level the ABS does not measure "net capital stock", but measure "gross fixed capital formation", which is the value of acquisitions less disposals of new or existing fixed assets. The intrinsic difference between the ideal measure and gross fixed capital formation is that the latter only calculates the formation of new capital and does not include existing capital or accumulated depreciation.

The measurement of capital stock has troubled economists for some time. Solow (1957) noted that what belongs in a production function is capital in use, not capital in place, and made an adjustment to account for idle capital. The majority of studies that have followed Solow (1957) have had to make adjustments to capital stock data to account for technical or conceptual limitations. In the absence of an ideal data set for capital stock in the Northern Territory, this thesis will create a synthetic net capital stock measure.

Two options were considered in creating a synthetic net capital stock estimate for the Northern Territory:

1. Calculate the Northern Territory's share of total gross fixed capital formation for each period and apply this proportion to the national net capital stock estimate;
2. Determine starting capital stock by calculating the Northern Territory's share of national net capital stock, then for each period add the Northern Territory's gross fixed capital formation, and account for depreciation.

Both options were tested to consider which produces results that are more characteristic of a net capital stock data set. The first option produced results that were highly volatile: the average rate of growth over the sample period was 8.1 per cent; the largest decline in a given period was 26 per cent; and the largest increase in a given period was over 45 per cent. These results are not consistent with the characteristics of net capital stock data sets. The second option produced less volatile results: in all periods after 1995 net capital stock increased; the average growth rate over the sample period was 3.5 per cent; the largest decline in a given period was less than 3 per cent; and the largest increase in a given period was less than 14 per cent. These results are more consistent with the characteristics of net capital stock data sets, although it is still more volatile than national figures. Both options were also trialled in the Solow (1956) growth model. As expected, the first option produced highly volatile estimates due to significant increases or decreases in the capital stock; the second option produced more stable estimates that were consistent with the studies that are presented in the literature review.

In terms of methodology, the second option is similar to that employed by other studies that have calculated net capital stock for Australian States and Territories. Louca (2003) obtained the starting capital stock by decomposing national net capital stock using each jurisdictions share of gross fixed capital formation; while the Productivity Commission (2007) divided the prevailing gross fixed capital formation figures by the assumed rate of deprecation and capital stock growth rates for each jurisdiction. Based on the results and the example of other studies, the second option has been selected to calculate net capital stock for the Northern Territory. The methodology is described in detail below.

First, the starting capital stock for the first period needs to be established, this is calculated as follows:

$$K_b = (FK_b \,/\, NFK_b) \text{ x } NK_b \qquad (4.1)$$

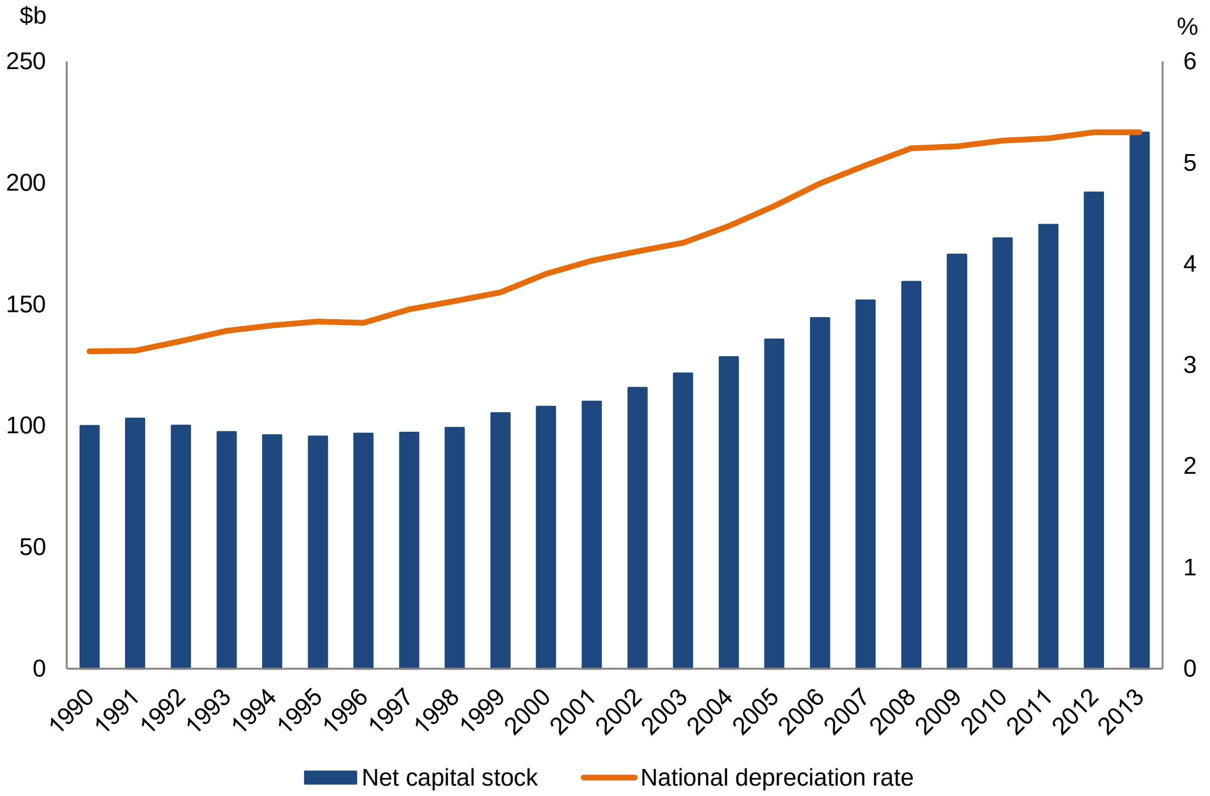
Where *K* is the Northern Territory's net capital stock, *FK* is the Northern Territory's gross fixed capital formation, *NFK* is national gross fixed capital formation, *NK* is national net capital stock, and *b* is the period ending June 1990. Using this formula the Northern Territory's share of national gross fixed capital formation was 1.4 per cent which as a proportion of national net capital stock equates to $29.9 billion and becomes the base of existing capital. In subsequent years the Northern Territory's net capital stock is calculated as follows:

$$K_t = (K_{t-1} \times 1\text{-}\delta) + FK_t \tag{4.2}$$

Where K_t is the Northern Territory's net capital stock, FK_t is the Northern Territory's gross fixed capital formation, δ is the national depreciation rate, and t is the given period. The national depreciation rate is calculated using data from the Australian National Accounts (ABS, Cat. 5204.0). The depreciation rate is derived by dividing the total consumption of fixed capital for a given period with the net capital stock of the same period. The ABS defines the consumption of fixed capital as the difference between the real economic value of an asset at the beginning of the period and at the end of the period, determined by the expected economic life of the asset. This data is only available at a national level, so in the absence of state level data these estimates will be used for the Northern Territory. Data for periods ending June 2012 and June 2013 are also not available, so the average growth in depreciation will be applied to the last available figure to produce the missing estimates. The national depreciation rate for each period is outlined in Appendix A.

Figure 4.1 illustrates the evolution of the Northern Territory's net capital stock and the national depreciation rate, both of which are estimated using the methodologies outlined above. The net capital stock estimate is expressed as an index (with the period ending June 1990 = 100).

Figure 4.1: Net capital stock for the Northern Territory, and national depreciation rate, 1990-2013.



Source: ABS 2013, Cat. No. 5204.0, Australian National Accounts
Notes: The data and methodology used to calculate net capital stock is outlined in Section 4.2.2

4.2.3 Labour

Total employment in persons will be used as the proxy for the labour variable as it captures movement in the labour stock. This data will be derived from the ABS, which produces monthly estimates of the total labour force and employment for all States and Territories (ABS, Cat. 6202.0). The data is available from 1978 to the end of the sample period.

The data is reported on a monthly basis, and is available in either original or trend estimates. Trend estimates in this context is the smoothing of seasonally adjusted data to produce series that illustrate the underlying trend. The ABS explains that this reduces the impact of the irregular component of the seasonally adjusted series (ABS, Cat. 5202.0). The trend estimates are derived by applying a 13-term Henderson-weighted moving average to all months except the last six. The last six trend estimates are derived by applying surrogates of the Henderson average to the seasonally adjusted series. While trend series would be useful for this model in analysing the underlying behaviour of the data over time, the ABS cautions that trend estimates for the Northern Territory have a high degree of variability because of the smaller sample size, which can lead to considerable revisions each month (ABS, Cat. 6202.0). For this reason the model will use original numbers that are not adjusted.

There are a number of other indicators that accompany the ABS's data sets that can assist in understanding the labour market in the Northern Territory. These indicators include: distinction between part-time and full-time work; aggregate monthly hours worked; and the underemployment rate, which captures those who are currently employed but are willing and able to work more (Ross and Whitfield, 2009). Across the sample period the Northern Territory's underemployment rate was the lowest of all jurisdictions at 4 per cent (ABS, Cat. 6202.0). It was not considered statistically significant to make an adjustment.

4.2.4 Factor shares

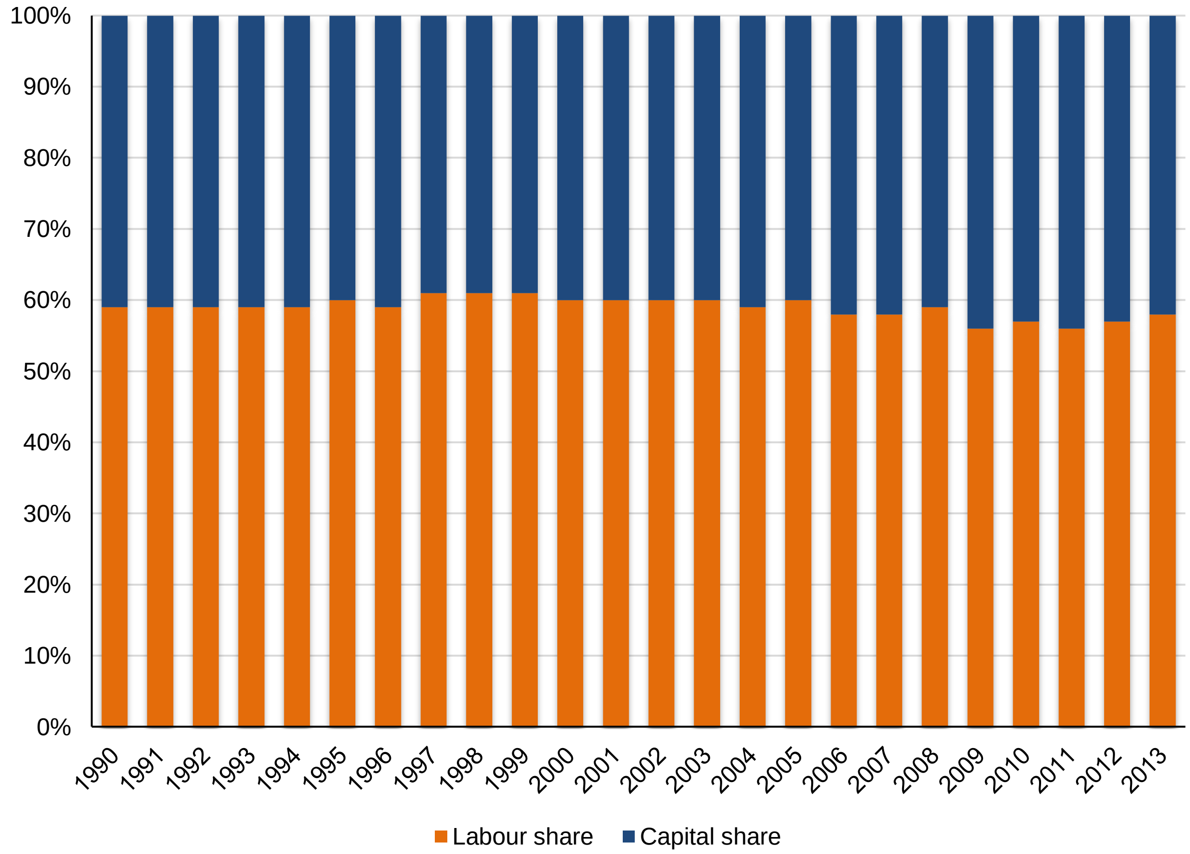
To estimate the Solow (1956) growth model, estimates for the factor shares are required. Solow assumed constant returns to scale, so that combining the capital share α and the labour share β should equal one. Therefore, if a value for either α or β is obtained, the other value could be solved by subtracting one by the known value ($1 - \alpha$ or $1 - \beta$).

The ABS has annual estimates for multi-factor productivity (MFP) (ABS, Cat. 5260.0). This data set includes national level estimates for labour and capital income shares, organised by sector. Given the scarcity of work in this area, it would be appropriate to use the national level estimates as a proxy for the Northern Territory. However there are several questions as to whether this is relevant to the Northern Territory, given that the composition of the Northern Territory economy is quite different to the national economy (Chapter 3). To make the factor shares more relevant to the Northern Territory, one option is to take the national level factor shares by sector and derive a weighted average based on the contribution of each sector to the Northern Territory's output. This alternative method was trialled and showed that the Northern Territory's factor shares are materially different to the national average: nationally the labour share was 0.58 and the capital share was 0.42 for the last period; while using the method described above the Northern Territory's labour share was 0.53 and the capital share was 0.47 for the same period. The difference is consistent with the analysis in chapter 3 which concluded that the Northern Territory economy is more capital intensive that the national economy. However, the ABS's estimates of factor shares do not include production from the 'non-market sector'. This means production from government dominated sectors are excluded as these goods and services are not for sale or sold at full price; while the ownership of dwellings is excluded as it is assumed there is no labour associated with this sector. It is worth noting that in 2012-13 these four sectors made up approximately 30 per cent of total output in the Northern Territory, while the government sector is the largest employer in the jurisdiction. Therefore excluding the government sector is likely to understate the labour share of production, suggesting that if it was included the Northern Territory's weighted factor shares would be closer to the national factor shares.

Based on the above considerations the national factor shares will be used for the Solow (1956) growth model and applied to each period. For the first 5 periods where national factor shares are not available, the long-term average of the factors shares will be applied. It is observable that the factor shares do not vary much over the sample period and using average factor shares would be appropriate. Appendix B outlines the national factor shares over the sample period.

Figure 4.2 illustrates the national capital and labour incomes shares graphically, which shows that they have remained relatively constant over the sample period.

Figure 4.2: National capital and labour income shares, 1990-2013



Source: ABS 2013, Cat. No. 5260.0.55.002, Estimates of Industry Multifactor Productivity
Note: for first 5 periods income shares were not available and the long term average shares was used.

4.2.5 Growth rates

The growth rate for each input is derived using a basic equation that quantifies change. The following equation is used, where *X* can represent any factor:

$$\dot{X}_t = \frac{X_t - X_{t-1}}{X_{t-1}} \tag{4.3}$$

4.3 Application of the Solow growth model

As discussed in Chapter 2, Solow (1956 and 1957) demonstrated that it is technological progress that is essential for long term growth. In this section the Solow growth model is used to estimate the level of technological progress in the Northern Territory. First, the methodology is explained, followed by a literature review of other studies that have estimated technological progress using the Solow growth model as a framework.

4.3.1 Methodology

This section describes the methodology that will be used to estimate the three components of growth in the Solow (1956) growth model: the capital contribution to growth; the labour contribution to growth; and technological progress.

First, using the Cobb-Douglas production function the Solow (1956) growth model can be written as:

$$Y_t = A_t\, K_t^{\alpha}\, L_t^{1-\alpha} \tag{4.4}$$

Where A_t denotes technology progress, K_t is capital, L_t is labour, and α is the capital share. Using the rate of change function, 4.4 can be rewritten as:

$$\dot{Y}_t = \dot{A}_t + \alpha \times \dot{K}_t + (1 - \alpha) \times \dot{L}_t \qquad (4.5)$$

Therefore the rate of economic growth equals the rate of technological progress, plus the capital share times the change in capital stock, plus the labour share times the change in labour stock. The only unknown variable in Equation 4.5 is $\dot{A}_t$. To solve for the unknown variable Equation 4.5 can be rewritten as:

$$\dot{A}_t = \dot{Y}_t - \alpha \times \dot{K}_t - (1 - \alpha) \times \dot{L}_t \qquad (4.6)$$

Equation 4.6 takes output growth and deducts the capital and labour contribution to growth; what remains is technological progress or a proxy for total factor productivity (TFP) (Taylor 2007). TFP is often referred to as the "residual" because it reflects the influence on output of factors other than the augmentation of inputs (Cunningham and Harb, 2012). This methodology will be utilised to estimate $\dot{A}_t$ or TFP for the Northern Territory for the period 1990 to 2013.

4.3.2 Literature review

Since Solow outlined his growth model in 1956 and estimated TFP for the United States of America in 1957, numerous studies that have done the same for other economies; at the same time there have been numerous extensions made to the model to include a variety of exogenous and endogenous factors to better understand the nature of economic growth. Very few studies have estimated TFP for the Northern Territory; this section will briefly look at these, and also estimates of TFP for Australia and other economies.

In the early 1990s, the Solow (1956) growth model was used to analyse the extraordinary economic growth that was occurring in East Asia. In a famous study, Paul Krugman (1994) found that growth in these economies was being driven by factor accumulation and not technological progress. Krugman (1994) suggested that a consequence of this is that the production function would not shift upwards and that these economies would reach the steady state level, implying that economic growth would eventually fall as a result of diminishing marginal productivity. Krugman's (1994) conclusion was that economic growth driven by factor accumulation was not sustainable in the long-run.

In another famous study, Young (1994) applied the Solow framework of analysis to a wide range of countries, including Australia. Young (1994) estimates that Australia's annual TFP growth between 1970 and 1985 was 0.7, which is ranked 49 out of 118 countries sampled. Young's (1994) estimation of annual TFP growth is presented in Table 4.2.

Table 4.2 Annual growth of total factor productivity of selected countries, 1970-1985

1.	Egypt	3.5	23.	Guinea	1.4	45.	Turkey	0.8
2.	Pakistan	3.0	24.	South Korea	1.4	46.	Netherlands	0.8
3.	Botswana	2.9	25.	Iran	1.4	47.	Ethiopia	0.7
4.	Congo	2.8	26.	Burma	1.4	48.	Austria	0.7
5.	Malta	2.6	27.	Mauritius	1.4	49.	Australia	0.7
6.	Hong Kong	2.5	28.	China	1.3	50.	Spain	0.6
7.	Syria	2.5	29.	Denmark	1.3	51.	Kenya	0.6
8.	Zimbabwe	2.4	30.	Israel	1.2	52.	France	0.5
9.	Gabon	2.4	31.	Greece	1.2	53.	Liberia	0.4
10.	Tunisia	2.4	32.	Japan	1.2	54.	Paraguay	0.4
11.	Cameroon	2.4	33.	Luxemburg	1.2	55.	Honduras	0.4
12.	Lesotho	2.2	34.	Yugoslavia	1.1	56.	Portugal	0.4
13.	Uganda	2.1	35.	Tanzania	1.1	57.	USA	0.4
14.	Cyprus	2.1	36.	Columbia	1.1	58.	Belgium	0.4
15.	Thailand	1.9	37.	Sweden	1.0	59.	Canada	0.3
16.	Bangladesh	1.9	38.	Malaysia	1.0	60.	Algeria	0.3
17.	Iceland	1.8	39.	Malawi	1.0	61.	C. African Rep.	0.2
18.	Italy	1.8	40.	Brazil	1.0	62.	India	0.1
19.	Norway	1.7	41.	Panama	0.9	63.	Singapore	0.1
20.	Finland	1.5	42.	United Kingdom	0.9	64.	Sri Lanka	0.1
21.	Taiwan	1.5	43.	West Germany	0.9	65.	Fiji	0.1
22.	Ecuador	1.4	44.	Mali	0.8	66.	Switzerland	0.0

Source: Young (1994)
Note: the table only includes the top 66 countries from a total of 118 countries

In one of the earliest studies of TFP in Australia, Otto (1999) estimates that between 1959 and 1992 annual TFP growth was 1.43 per cent. The study concluded that TFP growth is not strictly exogenous and that there are non-technological shocks that contribute to its fluctuation (particularly demand shocks). The study also found that changes to factor utilisation have a significant impact on TFP growth.

In one of the first studies of TFP in Australian jurisdictions, Louca (2003) estimates that between 1986 and 2001 annual TFP growth for most jurisdictions was between 1.0 and 1.3 per cent. The research did not include the Northern Territory and the Australian Capital

Territory. Louca (2003) noted that while considerable attention was given to productivity trends at the national level in Australia, research at the sub-national level was sparse.

Similarly, the Productivity Commission (2007) estimates that between 1990 and 2005 annual TFP growth for most jurisdictions was between 1.2 and 1.5 per cent. The exceptions in this study were: the Northern Territory where TFP decreased by approximately 0.7 per cent per year; the Australian Capital Territory where there was little TFP growth; and Western Australia where TFP increased by approximately 2.0 per cent per year.

The Commonwealth Treasury (2009) published a paper exploring productivity growth in Australia. The paper estimates a simple aggregate production function in the Cobb-Douglas format using quarterly ABS data, and assumes that the capital share of income is 0.31 based on studies by Sala-i-Martin (1995). On this basis it was estimated that between 1990 and 2000 annual TFP growth was 1.5 per cent and labour productivity growth was 2.2 per cent. In contrast, the same estimates for the period between 1978 and 1990 had much lower results, suggesting that Australia experienced a spike in productivity growth in the 1990's (Commonwealth Treasury, 2009).

Cunningham and Harb (2012) studied TFP growth in Australian jurisdictions, and also found that in the 1990's TFP growth was relatively high at 1.8 per cent per year, and was driven by productivty gains in the largest jurisdictions, however the exception was the Northern Territory which was the only jurisdiction to experience negative TFP growth in this period. Between 1999 and 2005 annual TFP growth declined to 1.2 per cent with the largest states experiencing the most substantial declines in produtivity growth, however the exception was the Northern Territoy which experienced extraordinary TFP growth of approximately 3.0 per cent per year. Between 2005 and 2011 TFP growth in Australia was relatively low at approximately 0.1 per cent per year, with the Northern Territory and some other jurisdictions experiencing negative TFP growth. Cunningham and Harb (2012) also estimated TFP growth for each sector, finding that the mining and construction sectors are negative drags on TFP growth, while the manufacturing, financial and insurance services, and professional, scientific and technical services sectors made a postive contribution to TFP growth. Cunningham and Harb's (2012) estimation of TFP growth for the Northern Territory is presented in Table 4.3.

Table 4.3 Annual growth of total factor productivity, Northern Territory and Australia, 1990-2011

	1990-1999 %	1999-2005 %	2005-2011 %	Average %
Northern Territory	-0.8	3.0	-1.4	0.1
Australia	1.8	1.2	0.1	1.2

Source: Cunningham and Harb (2012)

In a study on the relationship between output variability and economic growth in Australia, Sinha and Macri (2000) found that output variability is negatively related to economic growth. While this study does not employ the Solow (1956) growth model, it is of interest given that as a small economy the Northern Territory's output fluctuates more than the Australian average.

In a more recent study, Kumar and Paradiso (2013) estimate the growth effects of education in Australia using an adjusted Solow (1956) growth model as the framework for their analysis. The research found that educational attainment has a small but significant permanent effect on the growth rate of per worker output in Australia (approximately 1 per cent of TFP growth rate).

4.3.3 TFP estimation

Table 4.4 shows the results of the TFP estimation for the Northern Territory economy.

Table 4.4: Estimate of TFP growth, Northern Territory, 1990-2013

Year	Y_t *\$ millions*	K_t *K1990 = 100*	L_t *(000)*	$\dot{Y}_t$	$\dot{K}_t$	$\dot{L}_t$	*Capital contribution*	*Labour contribution*	*TFP A*
1990	9,391	100	78						
1991	9,612	103	76	2.35%	2.95%	-1.66%	1.21%	-0.98%	2.12%
1992	9,318	100	75	-3.06%	-2.80%	-1.30%	-1.15%	-0.77%	-1.14%
1993	9,365	97	75	0.50%	-2.57%	-0.46%	-1.06%	-0.27%	1.83%
1994	9,205	96	75	-1.71%	-1.34%	0.60%	-0.55%	0.36%	-1.51%
1995	9,607	96	81	4.37%	-0.68%	7.75%	-0.27%	4.65%	-0.01%
1996	10,306	97	84	7.28%	1.26%	2.76%	0.51%	1.63%	5.13%
1997	10,537	97	87	2.24%	0.52%	3.88%	0.20%	2.37%	-0.33%
1998	11,101	99	90	5.35%	1.95%	3.27%	0.76%	1.99%	2.60%
1999	11,603	105	94	4.52%	6.19%	4.85%	2.41%	2.96%	-0.85%
2000	12,337	108	93	6.33%	2.41%	-1.10%	0.96%	-0.66%	6.02%
2001	12,524	110	95	1.52%	1.96%	1.79%	0.79%	1.08%	-0.34%
2002	13,066	116	100	4.33%	5.19%	5.55%	2.08%	3.33%	-1.08%
2003	13,261	122	101	1.49%	5.18%	0.72%	2.07%	0.43%	-1.01%
2004	13,627	128	98	2.76%	5.53%	-2.30%	2.27%	-1.36%	1.85%
2005	14,242	135	96	4.51%	5.59%	-1.82%	2.24%	-1.09%	3.37%
2006	14,738	144	99	3.48%	6.56%	3.06%	2.75%	1.77%	-1.05%
2007	15,566	152	104	5.62%	5.06%	5.05%	2.13%	2.93%	0.57%
2008	16,634	159	112	6.86%	5.04%	6.87%	2.07%	4.05%	0.74%
2009	17,444	171	117	4.87%	7.02%	4.77%	3.09%	2.67%	-0.89%
2010	17,664	177	120	1.26%	3.95%	2.30%	1.70%	1.31%	-1.75%
2011	18,002	183	121	1.91%	3.11%	1.28%	1.37%	0.72%	-0.17%
2012	18,813	196	123	4.51%	7.27%	1.16%	3.13%	0.66%	0.72%
2013	19,860	221	126	5.57%	12.59%	2.56%	5.29%	1.49%	-1.21%
Avg.				3.34%	3.56%	2.16%	1.5%	1.3%	0.59%

The first column of Table 4.4 indicates the period ending June. The next three columns show the data that is used to estimate growth in output, capital, and labour. The next three columns show the growth rates for each of these variables. The next two columns estimate the factor contributions to output growth. The final column estimates TFP growth for the period using the methodology outlined in Section 4.3.2.

The last row of Table 4.4 shows the average growth rates for the sample period. It can be observed that the Northern Territory's output growth was on average 3.34 per cent per year. Over the same period the average capital contribution to growth was 1.5 per cent, the average labour contribution to growth was 1.3 per cent, and TFP growth was 0.59 per cent. Therefore factor accumulation is the primary driver of economic growth in the Northern Territory, while TFP only makes a minor contribution. Figure 4.2 illustrates the results of Table 4.4 graphically.

Figure 4.2: Decomposition of economic growth in the Northern Territory, 1990-2013

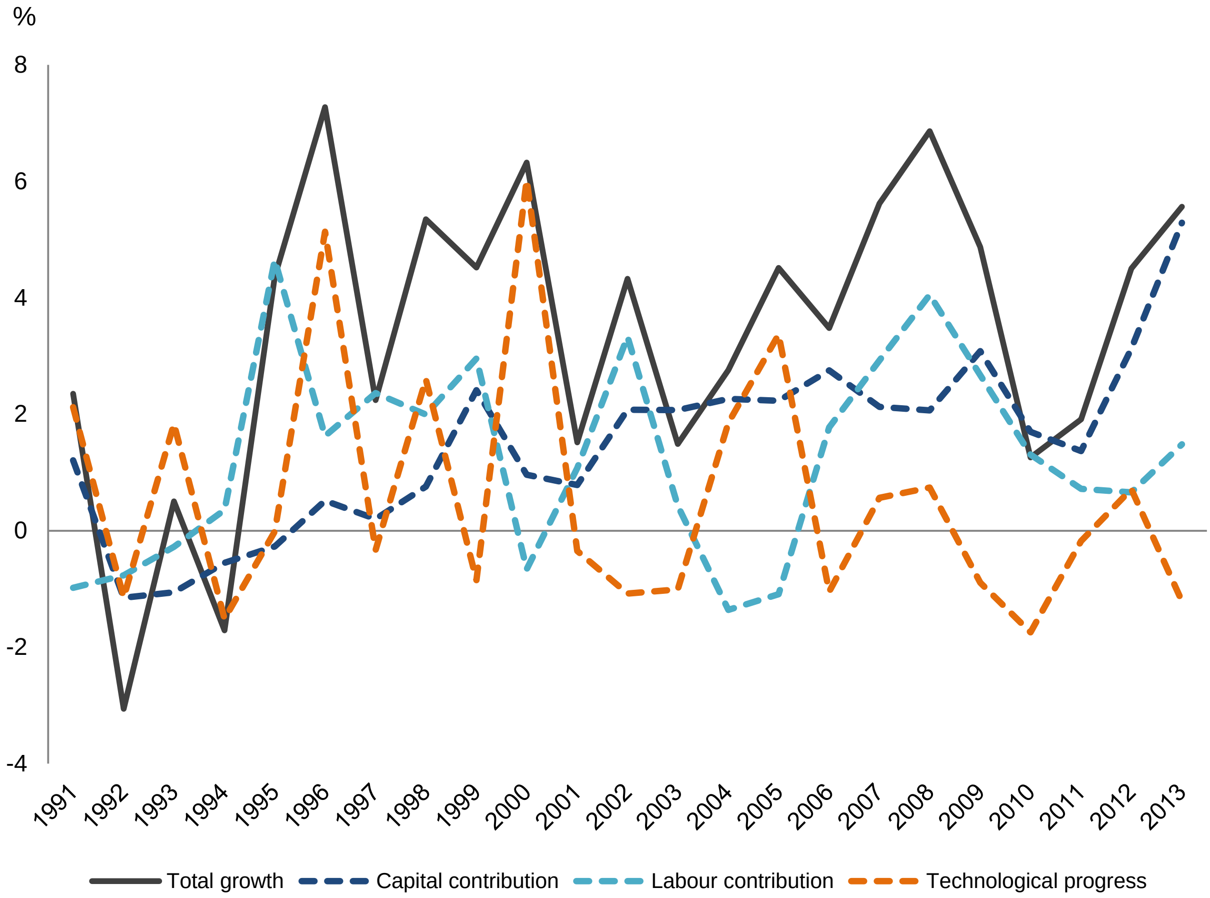
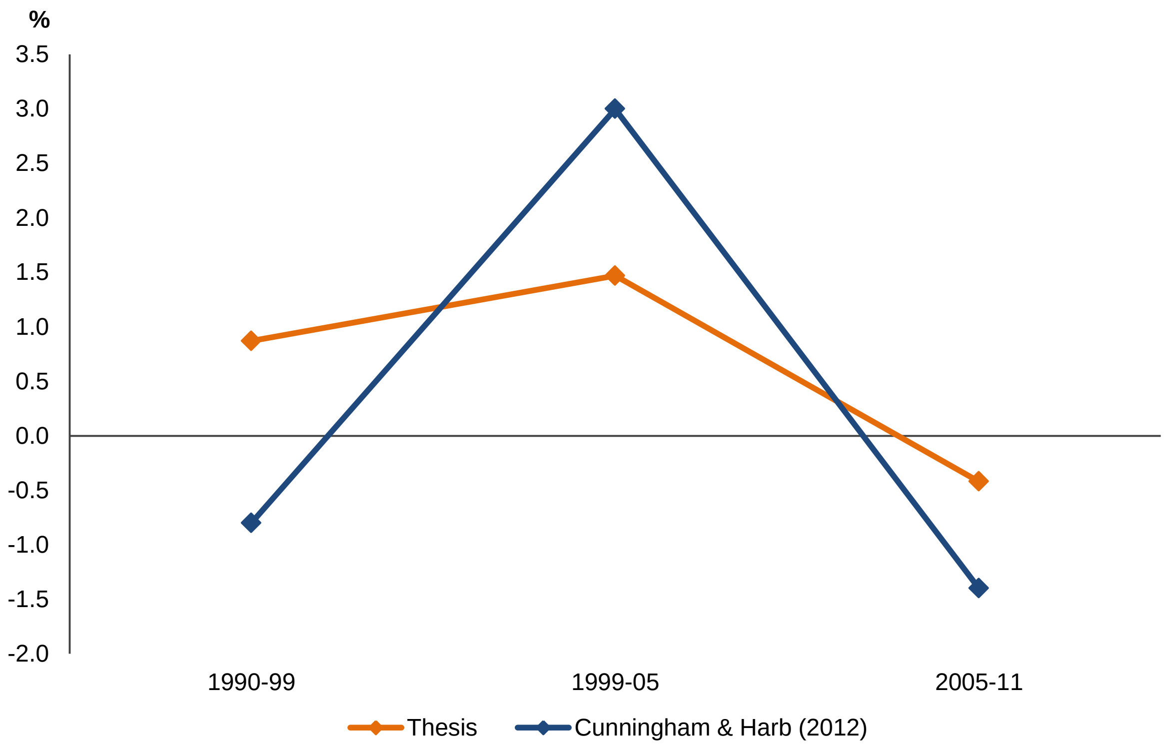


Figure 4.2 shows that TFP was relatively volatile over the sample period; for instance in 1999 TFP growth was -0.85 per cent, in the following period it was 6.02 per cent, then in the following period back down to -0.34 per cent. Figure 4.2 also illustrates that since 1999 capital growth and TFP growth have broadly had an inverse relationship. This observation is consistent with the trend analysis in Chapter 3, which found that economic growth is driven by resource projects that require large investments in capital; as capital growth is so large it crowds out TFP and in some periods makes it notionally negative even though "technological progress" may have actually occurred.

Table 4.4 shows that the Northern Territory experienced positive TFP growth in 10 periods. During those periods the average output growth was 4.61 per cent, which is higher than the long term average (3.34 per cent). Between 2004 and 2008 the Northern Territory experienced four periods of positive TFP growth. This is aligned with significantly above average output from the professional, scientific and technical services, financial and insurance services, and rental and real estate services sectors. This period was marked by: an increase in manufacturing production; the completion of a helium plant; the completion of a renewable fuels facility; increased alumina production; the establishment of two call centres; and a significant increase in household consumption (Department of Treasury and Finance, 2007). The strongest rate of TFP growth was achieved in 2000 at 6.02 per cent. In the same period, the labour contribution to growth was -0.66 per cent and the capital contribution to growth was 0.96 per cent, which are below the average over the sample period and attributable to a significant decline in non-dwelling construction activity. There are three periods where factor accumulation is negative (periods ending June 1992, 1993 and 1994), which coincide with the national recession; in two of these periods TFP growth was also negative.

The results of the empirical analysis are broadly similar to the Cunningham and Harb (2012) study. In terms of TFP growth over the sample period, Cunningham and Harb (2012) estimate that between 1990 and 2011 annual TFP growth in the Northern Territory was 0.1 per cent, which compares to 0.6 per cent estimated in this thesis for the same period. In terms of changes to TFP growth over the sample period the results follow a similar trend; both estimates show that TFP growth was strongest between 1999 and 2005, and similarly Cunningham and Harb (2012) attribute this to the professional, scientific and technical services, and rental and real estate services sectors. Figure 4.3 compares the trend in TFP growth between the estimates from this thesis and those from Cunningham and Harb (2012).

Figure 4.3: Comparison of TFP growth trends, estimates from this thesis and Cunningham and Harb (2012)



Source: Cunningham and Harb (2012)
Note: periods as selected by Cunningham and Harb (2012)

Table 4.4 decomposes the Solow growth model estimate into: average growth for the sample period, the last 10 periods, and the last 5 periods for all the variables. Additionally, correlation between output growth and the factors of productions are shown for the sample period.

Table 4.4: Solow growth model estimation for the Northern Territory decomposed, average annual contribution to growth, percentage share, and correlation, 1991-2013

	Output growth		Capital share		Labour share		TFP growth	
Sample period	3.34%	100%	1.48%	44%	1.27%	38%	0.59%	18%
Last 10 periods	4.13%	100%	2.60%	63%	1.32%	32%	0.22%	5%
Last 5 periods	3.62%	100%	2.91%	80%	1.37%	38%	-0.66%	-18%
Correlation with output	1.00		0.53		0.46		0.49	

Note: Correlation for sample period (1991-2013)

Table 4.4 shows that over the sample period capital growth made up 44 per cent of total output growth in the Northern Territory, labour growth made up 38 per cent, and TFP growth made up 18 per cent. Over the last 5 periods the proportions of growth have been markedly different; capital growth made up 80 per cent of total output growth, labour growth has remained the same at 38 per cent, while TFP makes a negative contribution to growth at -18 per cent. On average TFP is only a relatively small component of growth and in periods where there is strong capital growth it becomes negative. It is noticeable that the labour contribution to growth over all three time brackets is consistent. Even during the last 5 periods where there has been a significant expansion of the resources sector, a comparable increase in labour growth is not apparent, as the resources sector is not labour intensive. Further, the trend analysis in Chapter 3 indicates that labour growth lags behind output and capital growth.

Table 4.4 shows positive correlation between output growth and capital growth over the sample period at 0.53, while the correlation between output growth and TFP is slightly weaker at 0.49, and weaker again between output growth and labour growth at 0.46. Although the correlation between output growth and the three components are positive, it is not very strong for statistical purposes, which is likely to be the consequence of volatility in the measures.

Using the Solow (1956) growth model it can be observed that the majority of economic growth is attributable to factor accumulation, while there is very little economic growth attributable to TFP. Based on these observations it can be suggested that the Northern Territory's production function does not shift upwards and as a consequence the economy would experience diminishing marginal productivity.

It can also be observed that the Northern Territory's economic growth was primarily driven by capital accumulation. Further, capital accumulation is volatile and clumpy, and dependent on the resources sector. Based on these observations, it can be suggested that the Northern Territory's economic growth is highly susceptible to volatility and not sustainable in the long run.

4.3.4 Alternative TFP estimations

Some alternative estimates of the Solow growth model were carried out. These included using the alternative capital stock figure explained in Section 4.2.2 and using the average factor shares for all periods. For the estimates using the alternative capital stock data, TFP growth was significantly weaker as a result of capital stock making a significantly larger contribution to output growth. Further, the net capital was highly volatile from period to period which is not consistent with other capital stock estimates, even in small economies which experience volatility from foreign investment (Stiglitz, 2004). In contrast, the estimates using the average factor shares for every period do not produce materially different results. Therefore, it was considered that neither alternative estimate is more reliable or sound than the current estimate.

4.4 Limitations

This section considers the limitations of the framework of analysis adopted in this thesis. First, criticisms of the neoclassical growth models are explored, followed by a discussion of the data issues.

4.4.1 Model

The neoclassical growth models have attracted a great deal of attention and criticism over time. Such criticisms have been both theoretical and technical in nature and evolved as new experiences have emerged.

Some of the earliest criticism of the neoclassical growth models was around the limitations of aggregating factor prices which led to the "Cambridge Controversy". Joan Robinson (1962 and 1971) made the initial criticism that aggregating both labour and capital is problematic due to the heterogeneous nature of both inputs. This criticism was focused more on capital. Hunt (1979) explains that while the aggregation of labour into man hours or employment figures is clear, the aggregation of capital is not; Hunt (1979) explains further that "if we say 100 labourers work for a week, the meaning is unambiguous. But what does it mean to say 100 capitals worked for one week?" Robinson (1980) also highlighted that the neoclassical economic growth models did not incorporate time, and questioned whether accumulation and distribution could be analysed within a static equilibrium framework. Harcourt (2003) summarises that the debate did not lead to any conclusions, as both sides were entrenched and in the end it became a question of epistemology; ultimately the neoclassical economists maintained that in the absence of alternative empirical analysis a simple model with simple assumptions was sufficient for analysis.

A key characteristic of the neoclassical growth model is that TFP is "exogenous", meaning that the economic and social forces that determine technological progress are left unexplained. For many growth theorists this characteristic of the model is viewed as a limitation and has motivated them to build on or change the neoclassical model so that TFP is explained. A result of this is the emergence of "endogenous growth models" which allowed TFP to be affected by variables within the economy. In Romer's (1990) model, growth is driven by the stock of human capital; the model suggests that an economy which devotes more human capital to the production of new capital goods will experience stronger growth than an economy which devotes more human capital to the final output sector. This is on the basis that innovation increases an economies productivity, and increases capacity for further innovation. Other prevalent endogenous growth models include Lucas's (1988) model which suggests that TFP is the result of improvements to human capital stock itself, and Grossman and Helpman's (1991) model which suggests that economic growth is driven by producing an expanding variety of goods and supported by the expansion of knowledge.

In recent years there have been suggestions that TFP growth is not a strong predictor for the long term growth prospects of an economy. Liang and Mei (2005) argue that the strong growth experienced in East Asian economies after the Asian Financial Crisis in the late 1990's contradict the Solow growth model hypothesis. Taylor (2007) considers that if TFP growth was an accurate indicator for long term growth, then we should have seen economic growth in countries such as Egypt, Pakistan and Congo surpass economic growth in East Asian countries, which has not been the case over the last two decades. Taylor (2007) further highlights that none of the top five countries for TFP growth have experienced relatively strong speeds of convergence, and are still behind in technology and industry. These criticisms are further compounded by studies that have found that TFP growth rates can be substantially different based on the methods used for calculation, which was illustrated by Sarel (1997) who calculated substantially higher TFP growth rates for East Asian countries to those calculated by Young (1994). The differences were mainly the result of using lower estimates of capital income shares, and using comparable data from one data-set rather than data from different national accounts.

4.4.2 Data

There are a number of limitations that need to be considered when using ABS data for the Northern Territory. Due to the Northern Territory's small economy and population, the data has limited coverage and is more susceptible to volatility. Taylor (2009) considers that population estimates in the Northern Territory are afflicted with large sampling errors and fluctuations. The same issues exist for estimates of employment growth (Territory Economic Review, 2013) and estimates of GSP growth which can be affected by large transactions. The ABS considers that unadjusted series for the Northern Territory have historically shown a high degree of variability which can lead to considerable revisions to seasonally adjusted estimates when seasonal factors are estimated.

It is also considered that the analysis of productivity growth is difficult because of significant short term fluctuations. Otto (1997) noted that short term movements in TFP can sometimes be related to the state of the business cycle rather than reflecting changes in technology. For this reason the Commonwealth Treasury (2009) study into productivity suggested that average rates of growth over the long run can provide a better indication of trend productivity. The analysis in this thesis is over 23 periods which is greater than some of the most well-known studies of TFP such as Young (1994) who analysed 15 periods.

4.4.3 Output

In this thesis, chain volume GSP is used as the measure for output. While GSP is the state equivalent of national GDP, the ABS considers that GSP is not as robust as GDP for a number of reasons. First, it is not possible to derive state level estimates of GDP that are equivalent to the national aggregate due to a lack of data. While estimates of state final demand and of international trade are available by state, there is no complete data on intrastate trade in goods and services or changes in inventories (ABS, Cat. 5216.0). Second, chain volume measures are derived by adjusting the current price estimates with a specially constructed deflator. The ABS considers that due to the incomplete nature of price and expenditure data at state level, the state deflators are not as accurate as the national deflators. Therefore, an expenditure based volume measure for the states cannot be derived with the same methodology used for the national measure (ABS, Cat. 5216.0).

In other studies of TFP growth, GNP has been used as a measure for output. One of the differences between GNP and GDP worth noting is that the former excludes all income earned on Australian production that is owed to foreign debt holders, while the latter includes this income. Some argue that GNP is in fact more appropriate measure in analysing Australian output given the high level of foreign debt and foreign investment particularly in the resources sector (Dixon et al. 2014). This would be even more relevant to the Northern Territory given that the resources sector makes up a larger proportion of output. Therefore, using GDP or the state equivalent GSP could be misleading.

4.4.4 Capital

Net capital stock is the ideal proxy for capital as it is a measurement of the total capital that is available for production. However, due to the absence of this measure for the Northern Territory, this thesis uses a synthetic net capital stock measure which is dependent on a number of variables and assumptions.

One such variable is the depreciation rate. The national depreciation rate that was used in the synthetic net capital stock measure may not be applicable to the Northern Territory given the material differences in the physical and economic environment. The implication of this can be quite significant -- one study found that a one per cent change in depreciation has the same effect on steady-state capital and income per capita as a one per cent change in labour or technology, variables that receive far greater attention (Schündeln, 2012).

While the construction of the synthetic net capital stock measure uses ABS data and is logically sound, the results may not be robust. Comparing the national results with those for the Northern Territory, it can be observed that the average growth rate over the sample period is close to identical; however, there are far greater fluctuations in the Northern

Territory's results periodically. This may be a factor of the relatively small size of the Northern Territory's economy, which is consistent with results from other small economies.

There are also conceptual issues when dealing with measures of capital stock. Schreyer (2003) considers that there is a dual nature to capital stock and for that reason there are two ways it can be measured. The first measure looks at capital in its function as a provider of services in production, and takes into account differences in productivity; the second measure looks at capital as a store of wealth, reflecting the market value of capital, and takes into account retirements and depreciation. This thesis uses 'net capital stock', which falls into the second category as a measurement of value; therefore, it does not reflect productivity explicitly. Schreyer (2004) considers that using 'net capital stock' data could result in biased estimates of TFP. There has also been criticism at a conceptual level of the capital variable in neoclassical growth models, such as the substitutability of capital and labour, and the aggregation of heterogeneous capital (Robinson, 1971),

4.4.5 Labour

In comparing trend and original employment data, the ABS considers that trend data is more useful in analysing the underlying behaviour of the data over the long run (ABS, 2013). However the ABS has cautioned that trend estimates for the Northern Territory exhibit a high degree of variability and are often subject to statistically significant adjustments. On this basis original employment data has been used in this thesis, the consequence of which is that that the impact of seasonal affects are not accounted for.

It was also considered that some estimates of TFP for Australia use total working hours for the labour input. This measure is also not particularly reliable for the Northern Territory because of its small sample size. The total labour force is a more robust indicator that has less scope for error compared to total working hours. Further, both Solow (1957) and Otto (1997) use changes in the total labour force in their estimates of TFP. However, Solow (1957) acknowledged that using the total labour force does not account for underutilised labour and he made an adjustment to the data using the proportion of idle capital as a rough proxy. This is also an issue when using Australian data as the ABS's definition of employment is quite generous, with one hour of work per week meeting the requirement. While the ABS produces underemployment data, it is considered that making an adjustment for the Northern Territory is not feasible; at the same time it is considered that not accounting for the underutilisation of the labour stock could overstate the impact of labour accumulation on output growth.

4.4.6 Conclusion

This section has highlighted that there are a range of limitations with both the Solow (1956) growth model and the data. Some criticisms suggest there are theoretical and technical deficiencies with the model and that it is not an accurate reflection of reality. Other criticisms consider that because TFP is derived as a residual the results are highly sensitive to measurement error. Therefore, the estimates presented in this thesis should be treated with caution.

Chapter 5 Findings and Conclusions

This Chapter provides a review of the findings. First, the economic analysis and estimates of TFP are synthesised to consider whether they are compatible, followed by a discussion of the policy implications, and then the conclusion.

5.1 Synthesis

Carson (2010) considers that the Northern Territory has a “strange” economic structure and lacks diversification which can negatively impact economic growth. A publication from the Bureau of Industry, Transport and Regional Economics found that between 1991 and 2001 the Northern Territory experienced widespread declines in industrial diversity (BITRE, 2003). Gerritsen (2010) suggests that the Northern Territory is afflicted with “growth without development” and that there is a “dual economy” dominated by resource extraction which is at the detriment of other sectors, for instance the industrial sector which experienced no structural change between the 1981 and 2006 Censuses.

Analysis in Chapter 3 confirms these observations, finding that economic growth in the Northern Territory is primarily driven by the resources sector, and to a lesser extent the construction sector and public sector, while other sectors have relatively insignificant impact on economic growth. Further, Chapter 4 found that economic growth is driven by factor accumulation, particularly capital accumulation attributable to the resources sector, and that TFP is usually negative.

The Productivity Commission (2007) found that the fastest growing states in terms of GSP and TFP appear to be the fastest growing in terms of research and development (R&D) with the exception of the Northern Territory. The Northern Territory was an outlier in the sense that it experienced weak GSP and TFP growth in the estimation period (1990-2002) but experienced strong R&D growth. This could be a result of the structure of the economy; Gerritsen (2010) suggests that the Northern Territory has an “encapsulated” export sector, implying that while significant revenue is generated from the export of minerals, gas, agriculture, and fisheries, these sectors have relatively poor multipliers for the economy. It may be the case that R&D expenditure in the export sector makes a relatively small contribution to the economy.

Eslake and Walsh (2011) suggest that Australia’s overall productivity slowdown is centred on the resources, agricultural, and utilities sectors; estimating that these three sectors made up 45 per cent of the total decline in productivity in Australia. Similarly, Cunningham and Harb (2012) estimate that between 2005 and 2011 TFP growth in the resources sector was negative, which is attributable to the large capital input that is required by resource projects.

Cunningham and Harb (2012) also found that the professional, scientific and technical services, financial and insurance services, hiring and real estate services, and wholesale trade sectors all contributed positively to TFP growth. The trend analysis in Chapter 3 indicates that these sectors are not prominent in the Northern Territory. For example the professional, scientific and technical services sector only made up 3 per cent of total output in the Northern Territory, compared to over 7 per cent for the rest of Australia; even in per capita terms, output from this sector is half the Australian figure.

Similarly, Gerritsen (2010) argues that the Northern Territory public sector does not contribute to economic development. In the context of this thesis and looking at the prevalence of technological progress, this may be the case. In 2010 the ABS released a publication with experimental estimates of R&D. The publication estimates that across Australia, state level government expenditure on R&D only made up 4 per cent of total R&D expenditure in 2008-09, with the most significant amounts of expenditure going towards health, environmental, and socio-economic objectives (ABS, Cat. 8112.0).

Based on this analysis, it could be suggested that the Northern Territory's relatively weak TFP growth is a consequence of the structure of the economy, and reflects the unique nature of its most dominant sectors.

5.2 Policy implications

The Solow (1956) growth model assumes that technological progress is exogenous, as such technological progress is not observable and the model does not provide any means to increase it. This thesis will explore the policy implications of the findings by using theories from endogenous growth models that describe technological progress and the means to increase it. The policy implications are framed from the perspective of government strategy.

Based on the empirical analysis in this thesis, most of the Northern Territory's economic growth is driven by factor accumulation. This is particularly the case for the last 5 periods, which is attributable to record levels of private investment in the resource and construction sectors. To ensure that economic growth is not severely impacted by a decline in private investment, policy makers should pursue a strategy that would stimulate technological progress.

Given the nature of knowledge, the benefits to society as a whole often exceed the benefits obtained by the individual or firm that generates the knowledge (Dowrick 1995). As a consequence the development of knowledge may suffer from a lack of incentive if it was left up to market forces. There is then the case for governments to subsidise the generation of knowledge for the benefit of wider society, especially considering the proposal by Solow (1956) that technological progress is essential for long term economic growth.

The Commonwealth Treasury paper into productivity trends in Australia (2009) considers that a number of conjectures have been made about Australia's spike in productivity in the late 1990's; these include opening up of the domestic economy to international trade, the adoption and development of new technologies, and increased R&D activities (Gruen, 2001; Parham, 2004).

On a national level Australia's total investment in R&D has been below the OECD average (OECD, 2013). Otto (1997) points out that this can be attributed to a number of different factors, including protection of domestic industry from international competition which impacts competitiveness, the lack of adequate managerial skills, and inadequate systems for exchanging knowledge between researchers. Similarly, Eslake and Walsh (2011) comment that the relative lack of regulatory and competitive reforms over the last decade, coupled with increased risk aversion, has diminished emphasis on entrepreneurship and innovation in Australia.

The Productivity Commission (2007) suggests that government support of R&D can substantially increase productivity in the economy. In this respect, the Northern Territory government could create policy that would facilitate "the diffusion of ideas from foreign knowledge flows; the promotion of innovation; and the intensification of competition" (Productivity Commission, 2007). As such, the Northern Territory government could focus on sectors that have a more widespread impact on the economy such as manufacturing, public services, communication, and technology.

Romer (1986) suggests that technological progress is the result of innovation and knowledge accumulation. A possible strategy could be for both levels of government to increase research grants for Charles Darwin University and other private and non-profit research bodies. The Northern Territory government could also grant research bodies' payroll tax exemptions to lower input costs and encourage them to establish or relocate into the jurisdiction.

Lucas (1988) suggests that technological progress is the result of improvements to human capital; a direct approach would be to improve the education system. While school curriculums are set by the Commonwealth government, the Northern Territory government is responsible for the funding and provision of education services. As such, the Northern Territory government could increase funding for education, or establish supplementary programs to address needs and improve outcomes.

Kaldor (1966) proposes that investments in capital that leads to the growth of the manufacturing sector will, in turn, lead to growth of labour productivity, and eventually lead to constant or increasing returns to scale in the entire economy through productive labour augmentation. Therefore, the faster the rate of growth in the manufacturing sector, the faster the rate of growth of productivity in the entire economy (Taylor, 2007). As such, the Northern Territoruy government could explore policies that support and expand the manufacturing industry.

Howitt and Aghion (1998) present a “Schumpeterian” perspective that suggests that capital accumulation and innovation are complementary factors in long term growth, and that a subsidy to capital accumulation could increase economic growth in the long run, independent of technological progress. This is also consistent with the Salter (1966) model which suggests that replacing retired old capital with new capital brings about technological progress, as workers accumulate experience with capital over time which translates to efficiency. An implication of both of these theories is that a degree of capital accumulation can stimulate technological progress. Therefore, policies that encourage business, particularly non-mining businesses, to invest in capital could be beneficial.

5.3 Conclusion

It was first outlined that the Northern Territory has in many respects a unique economic reality: the socio-demographic characteristics are marked by poor health and education outcomes; an above average proportion of the population live in remote or very remote regions; and the government which is the largest employer in the jurisdiction is highly dependent on Commonwealth government payments to deliver basic services. Yet despite this, the smallest economy in Australia is experiencing extraordinary economic growth compared to the rest of the nation. The question posed by this thesis was in relation to the nature of this economic growth and whether it can be sustained in the long run. The thesis set out to explore this question within the framework of the Solow (1956) growth model.

The trend analysis in Chapter 3 shows that while economic growth has been extraordinary in recent years, just three sectors made up over 60 per cent of total output growth; namely the resource, construction, and public service sectors. The analysis considered that the dominance of a few key sectors is symptomatic of the structure of the economy and similar to other small developing economies. Further, the economy lacks diversity and is volatile.

The empirical analysis in Chapter 4 confirms that economic growth is being driven by factor accumulation, such that over 80 per cent of economic growth over the sample period is attributable to growth in the capital and labour stocks. This means that less than one fifth of economic growth is attributable to TFP, which was notionally negative in over half of the periods. Therefore it is proposed that economic growth in the Northern Territory is not sustainable in the long run and will experience diminishing marginal productivity.

Chapter 5 explores the policy implications of the findings and suggests measures that could be adopted to stimulate TFP in the Northern Territory. This was approached on the basis that increase in TFP is the result of knowledge accumulation which is often an uneconomical enterprise and should be undertaken by governments. As such, government interventions that either improve educational outcomes, provide incentives for research, or reduce the risk for innovation are suggested.

However, there is consideration that the results of the analysis are sensitive to the choice of data and assumptions. Data for the Northern Territory is not available for a number of the inputs for the model, therefore synthetic or national data was used, or in other cases a proxy. Given the sensitivity of the results to the data, and the limitations identified with Northern Territory data, the findings of the thesis should be treated with caution and only serve as a point of reference.

Appendix

Appendix A: Depreciation rates

Table A.1 shows the derived national depreciation rate for the sample period which were calculated using net capital stock and the consumption of fixed capital estimates. The synthetic net capital stock measurement used in the thesis incorporates the national average deprecation rate found in the last column.

Table A.1: National depreciation rates, by industry, June 1990 to June 2012

Unit	Agriculture, forestry and fishing	Mining	Manufact.	Electricity, gas, water and waste services	Construction	Wholesale trade	Retail trade	Accomm. and food services	Transport, postal and warehousing	Information media and telecomm.	Financial and insurance services	Rental, hiring and real estate services	Prof., scientific and technical services	Admin. and support services	Public admin. and safety	Education and training	Health care and social assistance	Arts and recreation services	Other services	Ownership transfer costs	**All industries**
Jun-1989																					
Jun-1990	6.93%	4.43%	8.06%	2.39%	8.33%	5.49%	6.56%	3.73%	3.71%	5.73%	3.77%	3.23%	11.42%	4.75%	3.60%	2.22%	3.12%	2.98%	0.09%	2.88%	**3.10%**
Jun-1991	6.29%	4.68%	8.30%	2.47%	8.21%	5.83%	6.75%	3.76%	3.89%	6.03%	3.71%	3.27%	11.40%	4.72%	3.84%	2.39%	3.26%	3.10%	0.10%	2.45%	**3.13%**
Jun-1992	6.44%	4.68%	8.38%	2.48%	8.30%	5.78%	6.80%	3.65%	3.99%	6.08%	3.62%	3.19%	11.40%	4.72%	3.97%	2.45%	3.28%	3.20%	0.10%	2.30%	**3.14%**
Jun-1993	6.45%	4.88%	8.78%	2.50%	8.80%	6.07%	7.02%	3.73%	4.17%	6.46%	3.70%	3.26%	11.91%	5.00%	4.20%	2.57%	3.37%	3.40%	0.11%	2.40%	**3.24%**
Jun-1994	6.68%	4.98%	9.12%	2.50%	9.35%	6.35%	7.29%	3.86%	4.30%	6.61%	3.86%	3.42%	12.28%	5.23%	4.39%	2.70%	3.47%	3.59%	0.12%	2.56%	**3.34%**
Jun-1995	6.94%	5.09%	9.27%	2.55%	9.52%	6.37%	7.32%	3.97%	4.33%	6.63%	3.88%	3.48%	12.69%	5.72%	4.45%	2.81%	3.55%	3.69%	0.13%	2.59%	**3.39%**
Jun-1996	5.98%	5.28%	9.41%	2.62%	9.76%	6.45%	7.45%	4.02%	4.38%	6.72%	3.89%	3.58%	12.58%	6.01%	4.54%	2.94%	3.65%	3.67%	0.15%	2.86%	**3.43%**
Jun-1997	6.05%	5.36%	9.24%	2.63%	9.26%	6.35%	7.16%	4.03%	4.34%	6.49%	3.81%	3.50%	12.12%	5.94%	4.48%	3.00%	3.68%	3.51%	0.16%	2.98%	**3.42%**
Jun-1998	7.44%	5.54%	9.52%	2.70%	9.52%	6.47%	7.28%	4.12%	4.44%	6.51%	4.06%	3.57%	12.12%	6.21%	4.68%	3.12%	3.79%	3.48%	0.18%	3.05%	**3.55%**
Jun-1999	7.17%	5.64%	9.75%	2.77%	9.70%	6.64%	7.35%	4.28%	4.59%	6.64%	4.22%	3.63%	12.26%	5.94%	4.94%	3.25%	3.88%	3.55%	0.19%	3.18%	**3.63%**
Jun-2000	7.34%	5.72%	9.81%	2.89%	9.58%	6.64%	7.26%	4.27%	4.65%	6.78%	4.39%	3.62%	12.28%	5.97%	5.09%	3.38%	3.98%	3.48%	0.20%	3.50%	**3.72%**
Jun-2001	7.86%	5.99%	10.08%	2.96%	9.62%	6.69%	7.24%	4.24%	4.78%	6.96%	4.88%	3.67%	12.41%	6.09%	5.50%	3.59%	4.14%	3.65%	0.22%	3.71%	**3.90%**
Jun-2002	8.24%	6.22%	10.33%	3.05%	9.80%	6.86%	7.29%	4.37%	4.87%	7.11%	5.04%	3.71%	12.48%	6.19%	5.75%	3.72%	4.24%	3.79%	0.23%	4.22%	**4.03%**
Jun-2003	8.08%	6.43%	10.44%	3.09%	9.97%	6.93%	7.31%	4.52%	4.96%	7.01%	5.17%	3.80%	12.34%	6.13%	5.78%	3.84%	4.34%	3.88%	0.24%	4.72%	**4.12%**
Jun-2004	7.84%	6.55%	10.12%	3.15%	9.81%	6.94%	7.14%	4.62%	4.96%	6.85%	5.11%	3.84%	11.97%	5.97%	5.62%	4.01%	4.42%	3.94%	0.24%	5.57%	**4.21%**
Jun-2005	7.51%	6.89%	10.26%	3.30%	10.05%	7.32%	7.27%	4.84%	5.12%	6.86%	5.39%	4.03%	12.21%	6.19%	5.82%	4.28%	4.61%	4.07%	0.25%	5.92%	**4.37%**
Jun-2006	7.86%	7.31%	10.44%	3.49%	10.25%	7.58%	7.42%	5.05%	5.33%	6.83%	5.69%	4.19%	12.60%	6.48%	6.04%	4.52%	4.81%	4.24%	0.27%	6.43%	**4.57%**
Jun-2007	7.82%	7.54%	10.43%	3.80%	10.54%	7.83%	7.57%	5.29%	5.55%	7.06%	6.02%	4.43%	12.81%	6.84%	6.20%	4.74%	5.04%	4.43%	0.30%	7.33%	**4.80%**
Jun-2008	8.40%	7.78%	10.52%	3.88%	10.79%	8.05%	7.67%	5.46%	5.65%	7.10%	6.29%	4.53%	12.93%	6.93%	6.18%	4.93%	5.20%	4.58%	0.32%	7.91%	**4.97%**
Jun-2009	8.54%	8.06%	11.01%	3.99%	11.45%	8.40%	7.91%	5.78%	5.96%	7.34%	6.72%	4.68%	13.31%	7.43%	6.61%	5.16%	5.45%	4.80%	0.36%	7.08%	**5.14%**
Jun-2010	8.33%	7.80%	10.95%	3.90%	11.27%	8.36%	7.77%	5.72%	5.75%	7.26%	6.78%	4.59%	13.27%	7.45%	6.39%	5.21%	5.41%	4.77%	0.39%	7.91%	**5.16%**
Jun-2011	8.44%	7.74%	10.77%	3.93%	11.04%	8.32%	7.66%	5.71%	5.72%	7.33%	6.97%	4.57%	13.07%	7.53%	6.22%	5.06%	5.46%	4.82%	0.40%	8.83%	**5.22%**
Jun-2012	8.29%	7.86%	10.76%	4.02%	10.95%	8.37%	7.55%	5.74%	5.80%	7.48%	7.18%	4.50%	13.00%	7.77%	6.15%	4.99%	5.57%	4.89%	0.43%	8.61%	**5.24%**
Average	*7.43%*	*6.19%*	*9.82%*	*3.09%*	*9.82%*	*6.96%*	*7.31%*	*4.55%*	*4.84%*	*6.78%*	*4.96%*	*3.84%*	*12.39%*	*6.14%*	*5.24%*	*3.69%*	*4.25%*	*3.89%*	*0.23%*	*4.74%*	***4.04%***

Source: ABS 2013, Cat. No. 5204.0, Australian System of National Accounts,

Appendix B: National factor shares

Table A.2 outlines the national factor shares that have been used in the empirical analysis. The estimates of national factor shares are sourced from the ABS. These estimates were not available for the first 5 periods, so the average over the sample period was used.

Table A.2: National factor shares, 1990 to 2013

Year	Capital share	Labour share
1990	0.41	0.59
1991	0.41	0.59
1992	0.41	0.59
1993	0.41	0.59
1994	0.41	0.59
1995	0.40	0.60
1996	0.41	0.59
1997	0.39	0.61
1998	0.39	0.61
1999	0.39	0.61
2000	0.40	0.60
2001	0.40	0.60
2002	0.40	0.60
2003	0.40	0.60
2004	0.41	0.59
2005	0.40	0.60
2006	0.42	0.58
2007	0.42	0.58
2008	0.41	0.59
2009	0.44	0.56
2010	0.43	0.57
2011	0.44	0.56
2012	0.43	0.57
2013	0.42	0.58
Average	0.41	0.59

Source: ABS 2013, Cat. No. 5260.0.55.002, Estimates of Industry Multifactor Productivity

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